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RESIDENTIAL WATER USE IN THE HARDISTY DISTRICT, EDMONTON, ALBERTA

by

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A THESIS

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The undersigned certify that they have read, and recommend to the Faculty of Graduate Studies for acceptance, a thesis entitled, "Residential Water Use in the Hardisty District, Edmonton, Alberta" submitted by EDWARD NEVILLE WARD in partial fulfilment of the requirements for the degree of Master of Arts.

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ABSTRACT

Residential water use should be a topic of interest to urban water planners because of the rapidly increasing number of residences being constructed in Canada's major urban centres. Intra-community, single family residential water use within the Hardisty district of Edmonton is the topic of research of this thesis. Data were gathered through mail questionnaires plus public records. The questionnaire sample of 271 represents 64.5 per cent of the sample of 420 residences.

Data were compiled for hypothetical price increases and water use habits. To a hypothetical 10 per cent increase, the majority of Hardisty residences indicated that they would not use less water. To a hypothetical 50 per cent increase, the majority said that they would use less water. Studies in other cities provide no conclusive evidence that people will reduce water consumption in response to such increases. Consumption may be initially reduced in response to such increases, but over a period of time a gradual return to former levels of consumption may occur.

Lawn watering is the factor which affects peak hourly and peak daily demands to the greatest extent. The excess of summer season over winter season water use can largely be attributed to lawn watering habits. Correlation and linear

regression analyses were performed between the quantity of water used per Hardisty residence from June, 1969 to August, 1970 and each of ten explanatory factors which have been noted in other studies.

The results of the Hardisty study are inconclusive. Such results provide a quantity of basic data. A purpose to which this data could be applied is aiding Edmonton Water Department officials in planning future water distribution. Single family residential growth within Edmonton will continue to expand. The accuracy of peak hourly and peak daily demand forecasts must continue to increase in order to increase the efficiency of the water distribution system. Complementing these forecasts should be studies of price increases and subsequent effects on consumption. On January 1, 1971, the price of water in Edmonton was increased by 10 per cent. An excellent opportunity exists for studying the effects of this increase on consumption. The Hardisty data will serve its most useful purpose if this information contributes to increasing the efficiency of water use, aids in reducing peaking problems and provides data for future water use planning within Edmonton.

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INTRODUCTION

The Problem

There is an increasing number of single family residences being constructed in Canadian cities. The water use habits of the occupants of such residences are a concern of urban water planners. The water distribution system of each city should be designed so as to meet peak hourly and peak daily water demands. Very closely associated with residents' water use habits is the water rate schedule of each city.

The Objectives

The Hardisty study, which is an attempt to measure the water use habits of residents within an intra-community context, has three objectives. The first objective is to determine the suitability of mail questionnaires plus public records for obtaining single family, intra-community residential water use data.

The second objective is to analyse water use and the responses of residents to hypothetical 10 per cent and 50 per cent price increases. This data may provide some insight into water use habits and associated price increases. Future water systems planning should incorporate a measure of water price--water use relationships in an attempt to increase the

efficiency of the water distribution systems and to reduce peaking problems.

The third objective is to evaluate the extent to which various factors correlate with Hardisty residential water use. The relationships between these factors and water use, plus the significance levels obtained by statistical analyses performed, may prove useful for comparison purposes with the findings of future intra-community studies.

The Study Area

Hardisty was chosen as the study area for two reasons. In January, 1970 it was learned that the Edmonton Water Department planned to record water use in this district of Edmonton during the summer of 1970. The purpose of such recordings was to obtain readings for a primarily residential district in order to obtain data on peak hourly and peak daily water flows. A pitot tube (used for gauging the maximum hour and maximum day flows) was installed on 50th Street and 101st A Avenue. Unfortunately, because of high humidity in the chamber the ink in the recorder kept blotching. Some readings were taken in August, 1970 after the equipment had been repaired, but there were no recordings for the peak day, which for Edmonton was June 3rd, or for subsequent days during the summer. Therefore, such data were unavailable for this study. The Edmonton Water Department plans to monitor Hardisty in 1971.

The second reason for the selection of this area is the homogeneous residential nature of Hardisty. The readily definable boundaries of the study area provided a suitable area for an intra-community water use study. The size of the study area, in terms of the number of residential lots (2,772) was large enough to permit an unbiased and representative random sample of 420 residences to which mail questionnaires were sent.

Units of Measurement

All water data is expressed in imperial gallons. All costs are expressed in Canadian dollars and cents. The rate of exchange used to convert U.S. dollars to Canadian dollars is 8 per cent. Eight per cent is appropriate since all U.S. studies referred to for water cost figures are dated prior to the 1970 1.75 per cent exchange rate.

CHAPTER I

THE RESEARCH TOPIC

The urban population of Canada in 1966 represented 73.6 per cent[1] of the total population. The rate of increase over the ten year period from 1956 to 1966 was 37.4 per cent. Provincially, Alberta showed the largest (58.4 per cent) ten year increase in urban population growth. The rural population in Alberta decreased by 6.5 per cent. This rural-urban shift can largely be attributed to the rapid growth of the Calgary and Edmonton metropolitan areas between 1956 and 1966. Edmonton's 1966 Census metropolitan area population increased from 254,800 in 1956 to 401,299 in 1966, a 57.5 per cent increase.

Metropolitan areas across Canada are experiencing a great 'suburban explosion'. One of the necessities of all cities and suburbs is an adequate and dependable supply of water. But in order to provide such a water supply, city water authorities must have knowledge of factors affecting water use. The focus of this study is on intra-community, single family residential water demands. Among the variables

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[1] Canada, Dominion Bureau of Statistics, Census of Canada, 1966, Analysis and Methods, General Population Trends. Ottawa, Queen's Printer, 1969, pp. 22, 23 and 26.

which any city water authority must consider when planning for future residential water demands are population growth; present water use, land use and zoning regulations; the price of water; and technological change. Per capita use trends should be related to these factors. Periodic restudy and re-evaluation of these factors are necessary in order to incorporate quantities of new data and to keep abreast of increasing knowledge of water demand functions. Future demands are difficult to predict because of the dynamic economic and technological environment. Future residential water demands should be viewed in broad terms and predictions should not be solely based on mechanical extrapolations of recent trends. Co-ordination of the following factors is a must: utility company information; city and municipal water plans; building contractors' information on the size of lots plus number, price and size of houses; revisions to zoning and land use maps; and population statistics. Edmonton, like other Canadian cities, must plan its water use with foresight and knowledgeable predictions of future requirements.

The Research Topic Related to Edmonton

The distribution of water to the City of Edmonton and to the surrounding metropolitan area is the responsibility of the Edmonton Water Department, hereafter referred to as Edmonton Water. The figures in Table 1-1 are the water

TABLE 1-1

EDMONTON WATER CONSUMPTION, 1966 TO AUGUST, 1970

	Water Consumption (Millions of Gallons and Per Cent)					
	Commercial-Industrial		Domestic		Suburban	
Yr.	Gal.	%	Gal.	%	Gal.	%
1966	5,457.4	48.9	4,574.6	41.1	1,105.7	10.0
1967	5,986.7	49.4	5,018.9	41.4	1,114.2	9.2
1968	6,291.5	49.1	5,435.7	42.0	1,150.6	8.9
1969	7,026.0	51.8	5,306.9	39.1	1,235.6	9.1
1970 (To Aug. 31)	5,301.8	53.3	3,801.5	38.2	838.4	8.5

Source: Edmonton Water, Annual Reports 1967, 1968 and 1969, and Edmonton Water Records, 1970.

consumption figures from 1966 to August 31, 1970 (the termination date of this study) expressed in millions of imperial gallons. Prior to 1966, water accounts were divided into city accounts and suburban accounts. Commencing in 1966, Edmonton Water plus the Computer Department of the City established a computer program to code each customer. Customers were divided into commercial and industrial and domestic (residential) water use categories. Thus the three major categories of Edmonton water use are commercial and industrial, domestic and suburban. The suburban customers are the Provincial Government at Oliver, Federal Government at Griesbach Barracks, Canadian Forces Base Namao, County of Strathcona

Number 20 which in turn serves Sherwood Park and Leduc and the Edmonton International Airport, St. Albert and Inland Cement in the Municipal District of Sturgeon, Fort Saskatchewan and Redwater. Since 1959, 100 per cent of the city and suburban accounts have been metered.

Additional statistical data are provided in Table 1-2 concerning water use in Edmonton from 1966 through 1969 as outlined in Edmonton Water Annual Reports for the years 1967, 1968 and 1969.

The major factors correlated with the water demands of single family residences are family income; the number of persons per household; the number and type of water-using appliances and plumbing fixtures per household; the assessed house value; lot size and irrigable lawn area; occupation of household head; the price paid for water; climatic factors of precipitation, temperature, evapotranspiration and soil moisture deficit; and individual tastes, preferences and attitudes concerning water uses both within and outside a house.

Within a house, water is used for bathroom purposes, culinary functions, in water-using appliances and sometimes in heating and/or cooling facilities. The number and type of water-using appliances and plumbing fixtures are the major criteria for measuring inside water consumption.

Outside a house, water use is affected to the greatest degree by lawn irrigation as related to the size of the

TABLE 1-2

EDMONTON WATER USE, 1966 TO 1969

STATISTICAL DATA CATEGORIES	YEAR 1966	1967	1968	1969
1. Customers (Number)				
Domestic	82,066	84,032	87,232	87,396
Commercial and Industrial	3,040	3,197	3,376	4,284
Fireline	939	989	1,038	1,066
Percentage Metered	100	100	100	100
Population Served in City	381,230	393,563	410,105	422,418
Approximate Population Served in Suburbs	24,000	25,000	26,000	27,000
2. Water Pumpage (Millions of Gals.)				
Pumped into System	12,182.0	13,345.0	13,599.0	14,889.0
Sold to Domestic Customers	4,574.6	5,018.9	5,435.7	5,306.9
Sold to Commercial-Industrial Customers	5,457.4	5,986.7	6,291.5	7,026.0
Sold to Suburban Customers	1,105.7	1,114.2	1,150.6	1,235.6
Percentage Accounted for from Metered Sources	91.4	90.8	95.3	91.7
Peak Hour Pumpage--Millions Gals. per Day	92.0	95.0	101.0	127.9
High Day--Millions of Gals.	57.6	61.2	66.0	74.6
Mean Daily Consumption (Millions of Gals.)	33.4	36.6	37.3	40.8
3. Consumption (Gallons/Capita/Day)				
Mean Yearly Demand	82.4	87.3	85.2	90.8
Peak Hourly Demand Rate	227.0	227.0	232.0	284.8
High Day Demand	142.0	145.0	151.0	165.9

TABLE 1-2 continued:

STATISTICAL DATA CATEGORIES	1966	1967	1968	1969
4. Gross Revenue Per Million Gals. Sold	$395.74	$392.38	$435.50	$419.80
5. Water Revenue Produced (%)				
Domestic	58.6	56.4	55.6	55.0
Commercial-Industrial	34.4	37.0	38.0	38.3
Suburban	7.0	6.6	6.4	6.7

lot. Usually, the larger the lot, the larger the irrigable area and the greater the amount of water used. The climatic factors previously mentioned affect the amount of water used for lawn watering.

The Study Area

The area of study within Edmonton is located in the south-east section of the city (see Figure 1). The boundaries are: north--Capilano Crescent and 109A Avenue; south--101st Avenue and Highway Number 16A; east--40th Street; and west--Fulton Drive and Hardisty Drive. The study area will hereafter be referred to as the Hardisty area or Hardisty.

The incorporation of the study area into the City of Edmonton occurred as follows. There were two divisions, Hardisty and Gold Bar, which were separated by 50th Street. Hardisty, the boundaries of which were 109A Avenue, Highway Number 16A, 50th Street and 75th Street, was incorporated into Edmonton on January 1, 1954. Gold Bar, the boundaries of which were 109A Avenue, Highway Number 16A, 40th Street and 50th Street, was incorporated into Edmonton on August 1, 1956. Thus the study area comprises all of Gold Bar plus Hardisty, west from 50th Street to Fulton Drive and Hardisty Drive.

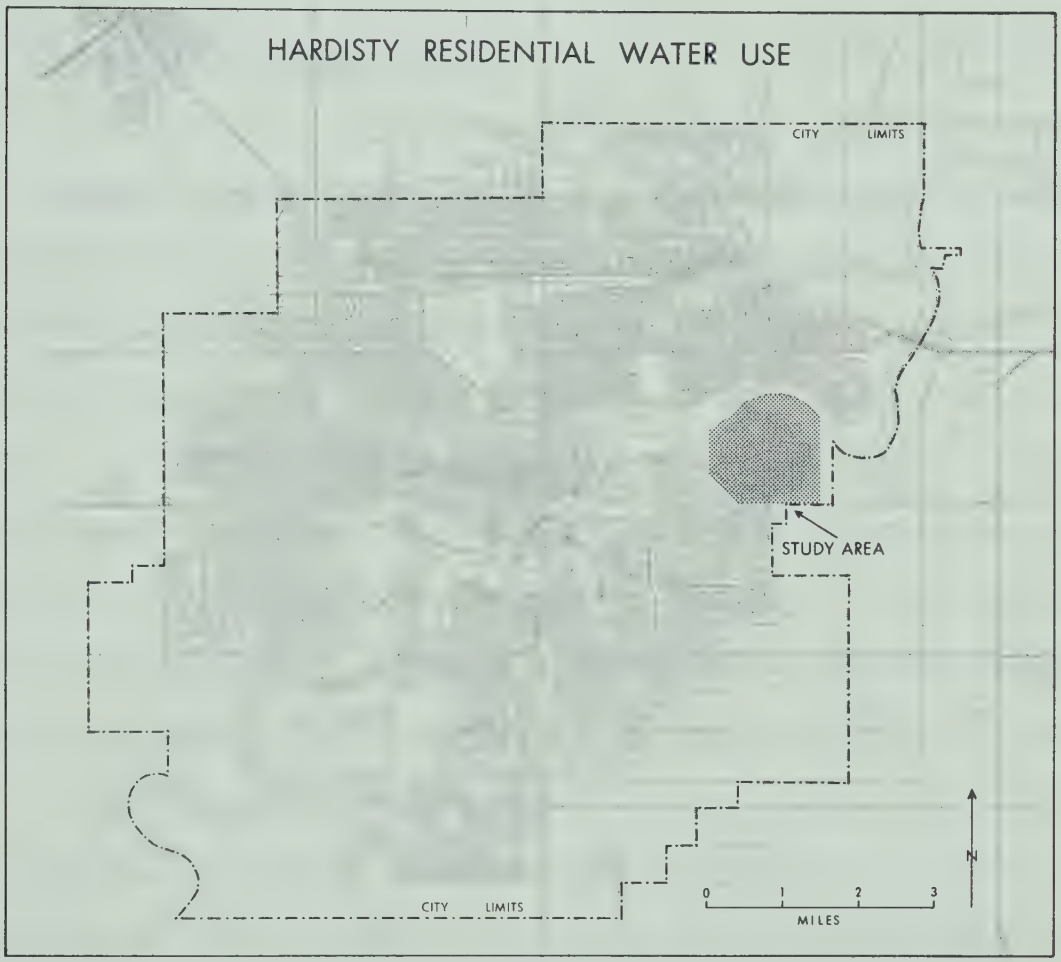
HARDISTY RESIDENTIAL WATER USE
CITY LIMITS
STUDY AREA
CITY LIMITS
0 1 2 3
MILES
N

FIGURE 1

CHAPTER II

DATA COLLECTION

A. The Pilot Questionnaire

In order to test the adequacy of the questionnaire--its layout, clarity of questions asked, and adequacy of the questions themselves--a pilot questionnaire and introductory letter (see Appendix A) were mailed to a sample number of houses in the Windsor Park district of Edmonton. Windsor Park is bounded by University Avenue, Saskatchewan Drive, 116th Street to 87th Avenue, and 117th Street to University Avenue. This district was selected because it was adjacent to the University of Alberta and provided a readily accessible suburban area at a time of an impending postal strike.

Forty pilot questionnaires were mailed. A self-addressed and stamped envelope was enclosed with each questionnaire. The sample of forty was selected with the aid of Henderson's Edmonton City Directory-Directory of Householders, 1969. Beginning at the north-west corner of 116th Street and Saskatchewan Drive, every fifth house was selected on 116th Street and the address and name of the householder recorded. This process was repeated for the other Streets, 117th to 120th, plus Saskatchewan Drive. Following selection of houses on the Streets, selection commenced on the north-west

corner of Edinboro Road and proceeded to include the Avenues within Windsor Park commencing with 93rd Avenue. Sixty addresses and names were selected from Henderson's Directory. The 1970 Edmonton and Vicinity Telephone Directory was consulted in order to verify names and addresses listed in the 1969 Henderson Directory. If a name and address in the Edmonton Telephone Directory did not correspond with that in the Henderson Directory, such a name and address was replaced. The method of replacement used was as follows. The first number from one to forty to be rejected was replaced by number forty-one; the second number by forty-two, and so on.

The number of questionnaires returned was twenty-eight out of forty--a rate of return of 70 per cent. No follow-up letter was sent.

The returned pilot questionnaires were analysed and the main survey questionnaire was designed. Differences between the two questionnaires can be seen by comparing Appendices A and B which respectively contain the pilot and main survey questionnaires plus appropriate introductory and follow-up letters.

The following is a brief explanation of why certain questions were omitted from the main survey questionnaire which had been asked in the pilot questionnaire.

Section A: Questions two and four were omitted as such data could be secured from assessment records.

Section B: The sentence between parts g) and h) of question one was added in order to ensure accuracy of responses.

Section C: Question three was omitted as the accuracy of responses was questionable. A constantly consistent figure could be obtained by subtracting the house, garage and patio areas from the lot areas.

Section D: The month in question two was changed in accordance with the most recent water bill which had been issued. Part e) of question three was omitted as it could be deduced from the answers given for parts a) and b).

Section E: Parts d), e), and f) were changed in order to ensure a university graduate category.

B. The Main Survey Questionnaire

Method of Sample Selection

The method of sampling used was area sampling. Copies of maps outlining each residential lot in the study area (Hardisty) were obtained from Edmonton Water. Each lot was numbered. There are 2,772 lots in the study area. The number to be sampled was 420 or 15 per cent of the total number of lots. This sample was chosen with respect to cost, time, and a return which would provide meaningful and representative data about the study area, a small homogeneous residential area. It was important that questionnaires be mailed early in June before residents began summer vacations. The threat of a postal strike also dictated early mailing.

A set of 500 random numbers within the limits of 1 to 2,772, inclusive, was obtained by using the APL terminal connected to the IBM 360 computer. The excess of eighty random numbers over the sample size of 420 was obtained in order to provide replacement numbers. The first 420 numbers selected by the APL terminal were transferred to the appropriate lot numbers on the aforesaid maps.

Replacements were made. Aerial photographs of Hardisty were viewed and a field check made in order to insure that the 420 selected households were single family residences.

The Department of Agricultural Economics and Rural Sociology, University of Alberta, is presently conducting a study to determine the effect of price on residential water consumption. Numerous towns and cities in Alberta are being examined. For Edmonton, a random sample of homes was selected throughout the city, including Hardisty, and questionnaires were mailed in 1968. In order to avoid sending questionnaires to the same people in Hardisty, the list of names and addresses used by the Department of Agricultural Economics and Rural Sociology was consulted and any duplicates were omitted and replaced. Six such replacements were made.

The lots which were randomly selected by APL each have a lot number and are located in numbered city blocks as outlined on the maps obtained from Edmonton Water. By

consulting the customer account cards of the Consumer Service Division, Edmonton Water, names and addresses were recorded for corresponding lot and block numbers. Customer account cards also provide the date when each occupant of a house began water service. For the Hardisty study, this date was taken to be the date when the occupant moved into the house. Any occupant of a house who had not resided at his address since June 1, 1969, was rejected and replaced because individual house monthly water data was to be collected from June 1st. Replacements were made for those houses which were in the process of being sold by real estate agents.

Questionnaire Response

The questionnaires were mailed in Department of Geography letterhead envelopes on June 8th. A self-addressed stamped envelope and cover letter were enclosed. The highest number of returns occurred on June 11th, 12th, and 15th, namely, thirty-six, thirty-seven, and thirty-seven respectively. By June 19th, 142 questionnaires representing 33.8 per cent of the sample had been returned. The first follow-up letter (see Appendix B) was mailed to non-respondents on June 21st. The highest number of returns following the mailing of the first follow-up letter occurred on June 29th, namely thirty-three. By July 7th, an additional 102 questionnaires representing 24.3 per cent had been returned. Therefore, by July 7th, 58.1 per cent of the questionnaires had

been returned. A second follow-up letter (see Appendix B) was mailed to non-respondents on July 7th. The returns following the second follow-up letter approximated two per day. The cut-off was July 24th by which day an additional twenty-seven questionnaires representing 6.4 per cent of the sample had been returned. The cut-off date was chosen in order that by mid-August individual house monthly water data plus assessment data gathering could be completed, except for August water consumption data. Computer coding could begin.

Therefore, the Hardisty area study was based on 271 questionnaires representing 64.5 per cent of the sample and 9.8 per cent of the entire population of 2,772 single family residences.

CHAPTER III

FACTORS AFFECTING HARDISTY WATER USE: A DESCRIPTION

The variation in water consumption between households in the Hardisty area is caused by many factors. One factor influencing consumption is price. Family income is another factor. It could be expected that the higher the income the greater the water consumption. This supposition is based on the premise that higher incomes permit and result in the ownership of larger houses with more water-using appliances, larger lots and larger lawns, all of which demand more water.

Water use inside a house is affected by the number of water-using appliances and plumbing fixtures. The greater the number of appliances and fixtures, generally the greater is the consumption of water.

Outside a house, water consumption is affected by lawn irrigation. The amount of water used is normally related to lot area minus the non-irrigable surfaces. For Hardisty, the irrigable area was equated to lot area minus house, garage and patio areas. As the area of the lot increases, it is expected that the amount of water used for lawn watering will also increase. Larger lots may have larger houses but not necessarily houses which consume more

lot area or proportion of lot area. The vertical plane may be used instead of expanding horizontally.

The factors of precipitation and temperature have a strong influence on the amount of water which a resident will use for lawn watering. Logically, as precipitation increases and temperatures decrease, evapotranspiration and soil moisture deficits will decrease. Thus less water will be required for lawn watering. For Hardisty, the summer season (lawn watering season) is defined as May to August. Lawn watering will be discussed later in this chapter.

Other factors which may be relevant in influencing household water use are occupation of the household head, assessed house value, and the number of persons per household. For Hardisty, water consumption will be expressed on a mean water use per household per month basis and also as a mean water use per household per day. The time period for this study is June, 1969 to August, 1970--fifteen months (457 days). This period will also be divided into the following time periods: June to September, 1969; October, 1969 to April, 1970; and May to August, 1970.

Sources of the Factors Utilized in Explaining Hardisty Water Use

Price: Water and sewage charges are contained in the brochure of The City of Edmonton entitled Waterworks Distribution System Tariff, December 4, 1961. Opinions of Hardisty residents with reference to the price paid for

water and reactions to hypothetical 10 per cent and 50 per cent price increases are obtained from questionnaire section D, question three. Price and water use will be discussed in Chapter IV.

A. Questionnaire Factors

As outlined in Chapter II, the number of questionnaires returned was 271 of 420 or 64.5 per cent of the sample. The following tables provide a summary of the responses to the questionnaire. Responses to section A, question two relating to the number of garages are not tabulated since such data plus garage areas were obtained from assessment data. The responses to section B, question two are not tabulated since the question should have asked how many loads of washing as well as times per week. Also the exact number of gallons per water-using appliance is not being considered.

1. Length of time resident has lived at present address

Table 3-1 summarizes, in months, the length of time Hardisty residents have lived at their present addresses. The majority of residents, 54.2 per cent, have lived in Hardisty for over 120 months or ten years. The mean value is 106 months or eight years and ten months. For the purpose of comparison, two Metropolitan Toronto residential areas are utilized. Dorset Park, located in Scarborough Township, had slightly more than 75 per cent of the same families residing in 1963 who were present in 1958. Families

TABLE 3-1

LENGTH OF TIME RESIDENT HAS LIVED AT PRESENT ADDRESS

Length of Time in Months	No.	%	
1 - 24	20	7.4	
25 - 60	56	20.6	
61 - 120	48	17.8	Mean - 105.98 Std. Dev. - 50.93
> 120	147	54.2	

Source: Questionnaire, Section A, Question 1

which appeared on the 1958 federal election voting list numbered 469. In Yorkminster, a residential distict within North York Township, 259 of 398 families (65 per cent) had the same address in 1963 as in 1958.[1]

Length of residence was an influential factor in the Hardisty questionnaire sample. If a residence had not been occupied by the same persons sine June 1, 1969, it was rejected. This date was determined by readily available water bill data.

2. Water-using appliances and plumbing fixtures

Table 3-2 provides a summary of the number of appliances and fixtures, the number of households and the percentage of households with each appliance and fixture. The five most common water-using appliances and plumbing fixtures

[1] S. D. Clark, The Suburban Society. University of Toronto Press, Toronto, 1966. p. 209.

TABLE 3-2

WATER-USING APPLIANCES AND FIXTURES

Appliance or Fixture	Number of Appliances or Fixtures	Number of Households	Percentage Households
Automatic Clothes Washer	0	27	10.0
	1	244	90.0
Clothes Washer (Wringer Type)	0	229	84.5
	1	40	14.8
	2	2	0.7
Automatic Dish Washer	0	205	75.6
	1	66	24.4
Garbage Disposal Unit	0	178	65.7
	1	93	34.3
Toilet	1	156	57.6
	2	100	36.9
	3	15	5.5
Shower	0	152	56.1
	1	109	40.2
	2	10	3.7
Bathtub	0	130	48.0
	1	140	51.6
	2	1	0.4
Shower/Bathtub Combination	0	123	45.4
	1	145	53.5
	2	3	1.1
Bathroom Sink	0	6	2.2
	1	157	57.9
	2	81	29.9
	3	24	8.9
	4	3	1.1
Single Kitchen Sink	0	207	76.4
	1	63	23.2
	2	1	0.4

Table 3-2 continued:

Appliance or Fixture	Number of Appliances or Fixtures	Number of Households	Percentage Households
Double Kitchen Sink	0	58	21.4
	1	212	78.2
	2	1	0.4
Single Laundry Tub	0	236	87.1
	1	34	12.5
	3	1	0.4
Double Laundry Tub	0	229	84.5
	1	41	15.1
	2	1	0.4
Water-Cooled Air Conditioner	0	265	97.8
	1	6	2.2
Furnace Humidifier	0	41	15.1
	1	226	83.4
	2	4	1.5
Portable Humidifier	0	247	91.1
	1	23	8.5
	2	1	0.4
Refrigerator with Automatic Ice-Making Device	0	233	86.0
	1	38	14.0
Other Taps	0	213	78.6
	1	22	8.1
	2	28	10.4
	3	2	0.7
	4	4	1.5
	6	2	0.7
Outdoor Taps	0	3	1.1
	1	183	67.5
	2	82	30.3
	3	3	1.1
Underground Watering System	0	271	100.0

Source: Questionnaire, Section B, Question 1.

are toilet, bathroom sink, automatic clothes washer, furnace humidifier and double kitchen sink. Only three houses did not have outdoor taps.

It is not within the scope of this study to examine the number of gallons of water used by each appliance and fixture per day. Such an examination would be beneficial in order to obtain a quite exact figure for household water use. Studies such as that by Anderson and Watson[2] proposed the recording of water consumption for individual appliances and fixtures.

Anderson and Watson measured average daily demands for each of eighteen test houses from January through April, 1966. A monitor recorded each eight gallons of flow which passed through the meters. Following the eight gallon study, appropriate adjustments were made to permit data collection at 0.8 gallon increments. Because of the large volume of data which would be accumulated, four test houses were selected. Daily hydrographs were plotted with regard to weekly usage patterns of appliances and peak water demands. Automatic clothes washers, dishwashers and food waste disposers were tested. Data was collected for two typical test houses over a seven consecutive day period. Home laundry, dishwasher and food disposer units averaged 0.7, 0.8 and 1.8 uses per day respectively.

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[2] J. S. Anderson and K. S. Watson, "Patterns of Household Usage". Journ. A.W.W.A., Oct., 1967, pp. 1228-1237.

K. S. Watson,[3] manager of the water management laboratory, General Electric Company, Louisville, Kentucky, studied food waste disposers and automatic dishwashers. The test of disposers was conducted using twenty-six telemetered houses over a two year period. The disposer was used on the average of 3.9 times per day for an average time of 2.18 minutes. The average flow rate per use was 3.5 gallons per day (gpd) at the normal setting, 5.2 gpd at the maximum flow with an aerator and 7.1 gpd at the maximum flow without an aerator. The 5.2 gpd figure is thought to be the most representative. The above figures were increased by 50 per cent to allow for drain flushing after the disposer had been turned off. Therefore, normal flow would be 5.3 gpd and maximum flow with an aerator would be 7.7 gpd.

For dishwashers, the average number of uses (cycles) per day was 1.5. The average number of gallons per cycle ranged from 5.8 to 10.4 gallons among manufacturers. The use per day (number of cycles times gallons per cycle) ranged from 8.7 to 15.7 gallons.

S. H. Bogue[4] outlined the number of gallons per minute (gpm) used by various appliances and fixtures as follows: wash basin, 2.5 gpm; tank toilet, 3.3 gpm; shower, 2.5 gpm;

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[3] K. S. Watson, "Water Requirements of Dishwashers and Food Waste Disposers". Journ. A.W.W.A., May, 1963, pp. 555-559.

[4] S. H. Bogue, "Trends in Water Use". Journ. A.W.W.A., May, 1963, pp. 548-554.

bathtub, 3.3 gpm; kitchen sink, 3.3 gpm; laundry tub, 4.2 gpm; automatic washing machine 2.5-5.8 gpm; automatic dishwasher, 2.1-4.2 gpm; and garbage disposer, 1.2-2.1 gpm. Home air conditioners range in capacity from three to ten tons and usually require 1.7 gpm per ton. Bogue stated that the rate of water use in the average house is 5.0-6.7 gpm when any two of the above fixtures are in use at the same time.

3. Lawn watering demands and related factors

From Table 3-3, the majority (82.7 per cent) of the persons in Hardisty indicated that they water their lawns between 6 and 9 P.M. The time when most persons (93.7 per cent) did not water their lawns was between 12 noon and 3 P.M. (taking into account that midnight to 6 A.M. was not asked). Such habits indicate that, consciously or subconsciously, persons watered their lawns at a time of day when rates of evapotranspiration are relatively low. Such habits are beneficial with respect to reducing losses of water through evapotranspiration. But this time may not be ideal with respect to demands on the water distribution system since it is reasonable to assume that the residential water use peak hour demand may be between 6 and 9 P.M. Such demands as lawn watering, dish washing, baths, showers, etc., are placed on the system. Only through recording the water use of individual appliances and fixtures in individual households could such assumptions be accurately tested.

TABLE 3-3

TIME OF DAY LAWN USUALLY WATERED
(RESPONDENT MAY CHOOSE MORE THAN ONE TIME)

Time of Day	Absolute Frequency			Relative Frequency (%)		
	No Response	Yes Watered at Time Indicated	No Do Not Water at Time Indicated	No Response	Yes	No
6AM-9PM	2	20	249	0.7	7.4	91.9
9AM-12 Noon	2	32	237	0.7	11.8	87.5
12Noon-3PM	2	15	254	0.7	5.5	93.8
3PM-6PM	2	36	233	0.7	13.3	86.0
6PM-9PM	2	224	45	0.7	82.7	16.6
9PM-12 Midnight	2	44	225	0.7	16.3	83.0

Source: Questionnaire, Section C, Question 1

Lawns and gardens in Hardisty were most frequently watered from one to two hours (39.5 per cent of the sample) or two to four hours (31.7 per cent of the sample) per day when watering occurred (see Table 3-4). From responses to questionnaire question three, section C, 164 (63.1 per cent) of the 260 respondents watered their lawns between one and ten times in May, 1970.

In Hardisty, the water use for swimming pools and wading pools can be disregarded because of the scarcity of such items; one and fifty-one respectively of the 270 respondents to these questions.

TABLE 3-4

LENGTH OF TIME LAWN AND GARDEN(S) WATERED EACH DAY ON DAYS WHEN WATERING OCCURRED

Length of Time in Hours	No.	%
<1	43	15.9
1 - 2	107	39.5
2 - 4	86	31.7
4 - 6	24	8.9
>6	8	3.0
Did not answer	3	1.0

Source: Questionnaire, Section C, Question 2

The amount of water used for irrigation purposes (lawns, shrubs, gardens) also depends on the lot area minus the non-irrigable area, defined for this study as house, garage and patio. Climatic variables such as temperature, precipitation and evapotranspiration, plus the soil moisture deficit, also affect the amount of water used for irrigation purposes.

A description of irrigable and non-irrigable areas, and climatic variables, is outlined in the next section of this chapter--description of other factors.

4. Number of persons per household

Hardisty had a 1969 Fall Civic Enumeration population of 13,264.[5] The population of Edmonton was 422,418 in the

[5]City of Edmonton, 1969 Fall Civic Enumeration. Edmonton, Jan. 15, 1970, 9 pp.

Fall of 1969. Thus in 1969, the study area represented 3.1 per cent of Edmonton's population. The mean number of persons per household in Hardisty was 4.38 (see Table 3-5). For

TABLE 3-5

NUMBER OF PERSONS PER HOUSEHOLD

Number of Persons	No.	%	Cumulative %	
Did not respond	3	1.1	1.1	
1	3	1.1	2.6	
2	28	10.3	12.9	
3	36	13.3	26.2	
4	82	30.3	56.5	
5	63	23.2	79.7	
6	27	10.0	89.7	Mean - 4.38
7	17	6.3	96.0	Mode - 4.00
8	7	2.6	98.2	Std. Dev. - 1.70
9	2	0.7	98.9	
10	3	1.1	100.0	
Total	271	100.0	100.0	

Source: Questionnaire, Section E, Question 1

Edmonton in 1966, the average number of persons per household was 3.5.[6] Howe and Linaweaver found that the number of persons per dwelling in metered areas ranged from 2.7 to 4.9.[7]

[6] Canada, Dominion Bureau of Statistics, Census of Canada, 1966, General Population Trends, Bulletin A-101. Ottawa, Queen's Printer, 1968.

[7] C. W. Howe and F. P. Linaweaver, Jr., "The Impact of Price on Residential Water Demand and Its Relation to System Design and Price Structure". Water Resources Research, Feb., 1967, p. 18.

For the period June, 1969 to August, 1970, the following per household water consumption and water bills were recorded.[8] The mean monthly water use was 7,048 gallons per household with a mean monthly cost of $3.84. The mean daily water use was 231 gallons per household with a mean daily cost of 13 cents. Since the mean number of persons per household was 4.38, the mean per capita water use per month and per day was 1,609 and 53 gallons, respectively (to the nearest gallon). The mean per capita cost of water per month and per day was 88 cents and 3 cents, respectively (to the nearest cent).

For the City of Edmonton in 1969, the mean yearly demand was 90.8 gallons per capita per day (see Table 1-1).

5. Occupation of the head of the household

In Hardisty, the most common occupational group was service workers and operatives, 34.3 per cent. The second most common group was professionals and managers, 31.7 per cent. Table 3-6 outlines the occupational categories and appropriate data regarding each category.

For Edmonton in 1961, the percentage employment by industry was used and the nine categories contained in Diagram 8 of The City of Edmonton General Plan[9] were grouped

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[8] Edmonton Utilities

[9] City of Edmonton, City Planning Department, The City of Edmonton General Plan. Edmonton, Aug., 1967, Diagram 8, p. 38.

TABLE 3-6

OCCUPATION OF HEAD OF HOUSEHOLD

Occupation	No.	%
Did not respond	15	5.5
Professionals and Managers	86	31.7
Craftsmen, Sales Workers and Clerical Workers	54	19.9
Service Workers, Operatives	93	34.3
Public Administration	13	4.9
Other	10	3.7

Source: Questionnaire, Section E, Question 2

into the five Hardisty occupational categories. Therefore, for Edmonton in 1961, occupational categories and respective percentages were: professionals and managers, 25.0 per cent; craftsmen, sales workers and clerical workers, 23.5 per cent; service workers and operatives, 37.5 per cent; public administration, 11.5 per cent; and other, 2.5 per cent.

For Edmonton, like Hardisty, the most common occupational category was service workers and operatives. In fact, all five categories for both Edmonton and Hardisty have the same order of ranking from highest to lowest per cent.

6. Income

Table 3-7 summarizes total yearly family income. The mean income range was $7,001 to $10,000 and was realized by 28.8 per cent of the Hardisty families.

From the 1961 Census of Canada[10], the mean family income for Edmonton families was $6,078. The income range of $7,000 to $9,999 was realized by 17.7 per cent of 1961 Edmonton families. Income levels and the value of the dollar have changed since 1961 and thus no direct comparisons can be made between the Edmonton and Hardisty incomes.

TABLE 3-7

TOTAL YEARLY FAMILY INCOME

Income Category ($)	No.	%
Did not respond	32	11.8
<3,000	4	1.5
3,001-5,000	7	2.6
5,001-7,000	15	5.5
7,001-10,000	78	28.8
10,001-12,500	49	18.1
12,501-15,000	43	15.9
15,001-17,500	15	5.5
17,501-20,000	16	5.9
>20,000	12	4.4

Source: Questionnaire, Section E, Question 3

7. Education

Table 3-8 summarizes years of education of the

[10]Canada, Dominion Bureau of Statistics, Census of Canada, 1961, Bulletin 4.1-3. May 21, 1964.

TABLE 3-8

YEARS OF EDUCATION OF HIGHEST MONEY EARNER OF HOUSEHOLD

Years of Education	No.	%
Did not respond	19	7.0
0 - 8	32	11.8
1 - 2 High School	54	19.9
3 - 4 High School	103	38.0
1 - 3 University	22	8.1
Univ. Graduate	26	9.7
Post Grad. Educ.	15	5.5

Source: Questionnaire, Section E, Question 4

highest money earner of each household. The mode was three to four years of high school education and represented 38.0 per cent of the sample.

For Edmonton in 1961, the largest percentage of the population, 10 years and over, not attending school, by highest grade attended was 26.8 per cent with five years plus of elementary schooling. Twenty-four per cent had one to two years of high school, 21.7 per cent had four to five years of high school, 4.5 per cent had some university and 4.6 per cent had a university degree.[11]

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[11] Canada, Dominion Bureau of Statistics, Census of Canada, 1961., adapted by City of Edmonton, Industrial Development Department, Education. May, 1969, p. 1.

B. Other Factors That May Affect Hardisty Water Use

1. Lot area and irrigable and non-irrigable areas

From Table 3-9, the mean lot area is 6,845 square feet. Data on non-irrigable areas--house, garage, patio--is

TABLE 3-9

AREA OF RESIDENTIAL LOTS

Area of Lot (Sq. Ft.)	No.	%	
3,500 - 5,000	1	0.4	
5,001 - 8,000	225	83.0	Mean - 6,845
8,001 - 10,000	40	14.8	Std.Dev. - 1,135
>10,000	5	1.8	

Source: Edmonton Water Maps

provided in Tables 3-10, 3-11 and 3-12, respectively. The

TABLE 3-10

AREA OF RESIDENCES

Area (Sq. Ft.)	No.	%	
600 - 800	6	2.2	
801 - 1,000	27	10.0	
1,001 - 1,200	187	69.0	Mean - 1,104
1,201 - 1,400	43	15.8	Std. Dev. - 139
1,401 - 1,600	5	1.9	
>1,600	3	1.1	

Source: Office of the Assessor and Tax Collector, City of Edmonton

TABLE 3-11

AREA OF GARAGES

Area (Sq. Ft.)	No.	%	
1 - 200	5	1.8	
201 - 400	123	45.4	Mean - 315
401 - 600	86	31.7	Std. Dev. - 183
>600	4	1.5	
Do not have garage	53	19.6	

Source: Office of the Assessor and Tax Collector, City of Edmonton

TABLE 3-12

AREA OF PATIO

Area (Sq. Ft.)	No.	%	
1 - 100	30	11.1	
101 - 200	77	28.4	
201 - 300	48	17.7	Mean - 158
301 - 400	18	6.7	Std. Dev. - 164
>400	15	5.5	
Do not have patio	83	30.6	

Source: Questionnaire, Section C, Question 6

mean total non-irrigable area per lot is 1,577 square feet as shown in Table 3-13. The irrigable area, defined as the lot area minus the sum of house, garage and patio areas, is summarized in Table 3-14. The mean irrigable area is 5,268 square feet.

The majority of Hardisty residents said that they would not use less water if there was a 10 per cent price

TABLE 3-13

TOTAL NON-IRRIGABLE AREA (HOUSE, GARAGE, PATIO) PER RESIDENTIAL LOT

Area (Sq. ft.)	No.	%	
900 - 1,500	112	41.3	
1,501 - 2,000	137	50.6	Mean - 1,577
2,001 - 2,500	20	7.4	Std.Dev. - 230
2,501 - 3,000	2	0.7	

TABLE 3-14

TOTAL LAWN (IRRIGABLE) AREA PER RESIDENTIAL LOT

Area (Sq. ft.)	No.	%	
≤3,000	1	0.4	
3,001 - 5,000	128	47.2	
5,001 - 7,000	127	46.9	Mean - 5,268
7,001 - 9,000	10	3.6	Std.Dev. - 1,420
9,001 - 11,000	4	1.5	
>11,000	1	0.4	

increase for water but would use less with a 50 per cent increase (see Chapter IV). This reaction appears to be quite normal. Irrigation (sprinkling) water uses are more price elastic than household water uses. There is a greater degree of flexibility possible with regard to the amount of water which can be used for sprinkling. For example, residents could water their lawns and shrubs less often. In new residential areas, sod could be planted which requires less moisture. The amount of high water consuming vegetation

could be reduced and replaced by a patio, for example. Any leaking hose and tap connections could be repaired.

2. Climatic factors

Temperature, precipitation, evapotranspiration and the soil moisture deficit[12] affect the amount of water used for irrigation purposes. The critical lawn watering season in Edmonton appears to be May through August. Table 3-15 provides a summary of the mean monthly temperatures and total precipitation for Edmonton City (Industrial Airport) from May through August in 1969 and 1970. This table also provides figures of monthly residential water use in Edmonton, monthly figures of evapotranspiration, potential evapotranspiration, soil moisture deficits and soil moisture storage. Soil moisture storage capacities of three, four and five inches are utilized. Because of the small size of the study area, the information contained in Table 3-15 is assumed to be relevant both for Hardisty and the City of Edmonton.

For the summer seasons of 1969 and 1970, calculations were made of the mean number of inches of water which were applied by Hardisty residents to the irrigable areas of their residential lots. The 1969 summer season for Hardisty is defined as June to September. Calculations of the monthly water use per residence for May and September, 1969 for

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[12] C. W. Thornthwaite and J. R. Mather, "The Water Balance." Publications in Climatology, Drexel Institute of Technology, Volume 8, Number 1, Centerton, New Jersey, 1955.

TABLE 3-15

CLIMATIC FACTOR VALUES FOR EDMONTON CITY (INDUSTRIAL AIRPORT) AND EDMONTON RESIDENTIAL WATER USE* FOR MAY TO AUGUST OF 1969 AND 1970

	1969				1970				1969	1970
	May	June	July	Aug.	May	June	July	Aug.	Total	Total
Mean Temperature Max./Min. (°F.)	52.7	60.4	62.4	62.5	52.9	62.6	64.1	63.1		
Total Monthly Precipitation (ins.)	1.31	0.98	3.29	4.50	0.69	3.59	6.80	0.89	10.08	11.97
Potential Evapotranspiration (PE)(ins.)	3.11	4.35	4.91	4.49	3.16	4.67	4.59	4.39	16.96	16.81
Evapotranspiration (ET) (ins.)	3.11	1.56	3.29	4.49	2.88	3.59	4.59	3.10(a)	12.45	14.16
	3.11	2.12	3.29	4.49	3.16	4.31	4.59	3.10(b)	13.01	15.16
	3.11	2.12	3.29	4.49	3.16	4.67	4.59	3.45(c)	13.01	15.87
Soil Moisture Storage (SMS) (Inches)	0.58	0.00	0.00	0.01	0.00	0.00	2.21	0.00(a)	0.59	2.21
	1.14	0.00	0.00	0.01	0.72	0.00	2.21	0.00(b)	1.15	2.93
	1.14	0.00	0.00	0.01	1.43	0.35	2.56	0.00(c)	1.15	4.34
Soil Moisture Deficit (D)** (Inches)	0.00	2.79	1.62	0.00	0.28	1.08	0.00	1.29(a)	4.41	2.65
	0.00	2.23	1.62	0.00	0.00	0.36	0.00	1.29(b)	3.85	1.65
	0.00	2.23	1.62	0.00	0.00	0.00	0.00	0.94(c)	3.85	0.94
Edmonton Residential Water Use (Millions Gallons)	457.9	601.3	627.3	533.3	494.6	629.1	610.4	526.2		

(a) Three Inch SMS (b) Four Inch SMS (c) Five Inch SMS

TABLE 3-15 continued:

*Includes all types of residences, not just single family.

**Deficit is calculated by Thornthwaite and Mather Procedures of 1955.

SOURCES:
1. Canada, Dept. of Transport, 1969 Annual Meteorological Summary for Edmonton, Alberta. Edmonton, 1970.
2. Weather Office Records for Industrial Airport, Weather Office, Edmonton International Airport.
3. Edmonton Water

Edmonton indicate a very small difference (0.57 gallons higher in September) in water use. There was no soil moisture deficit in either May or September. The substitution of May for September in Table 3-15 for the purpose of analysing lawn sprinkling should not detract from the accuracy of the following analysis.

To determine if the average Hardisty resident uses more water for lawn sprinkling than is necessary, a comparison was made between the mean number of inches of water applied to the mean irrigable area (5,268 square feet) per residence and the soil moisture deficits calculated for three soil moisture capacities (smsc), namely, three, four and five inches. Comparisons were made for both the 1969 and 1970 summer seasons (see Table 3-16). The mean number of inches of water utilized for lawn watering was 2.28 inches and 2.64 inches, respectively for 1969 and 1970. A study[13] published by the Northeastern Illinois Planning Commission indicates that about two inches of lawn water are sufficient in the Chicago area. Linaweaver, Geyer and Wolff[14] estimate the average actual lawn sprinkling in metered residences amounts to 4.7 inches and 7.4 inches during a summer, respectively, for the Eastern and Western U.S. From Table 3-16,

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[13] Northeastern Illinois Planning Commission, The Water Resource in Northeastern Illinois: Planning Its Use. Chicago, N.I.P.C., 1966, p. 68.

[14] F. P. Linaweaver, Jr., J. C. Geyer and J. B. Wolff, "Summary Report on Residential Water Use Research Project". Journ. A.W.W.A., Mar., 1967, p. 277.

TABLE 3-16

WATER REQUIRED AND WATER APPLIED IN HARDISTY DURING THE 1969 AND 1970 SUMMER SEASONS

1969		Soil Moisture Storage Capacity (Inches)		
		3"	4"	5"
Soil Moisture Deficit (inches)		4.41	3.85	3.85
Water Applied (inches)		2.28	2.28	2.28
Under-Application (inches)		2.13	1.57	1.57
Over-Application (inches)		-	-	-
1970				
Soil Moisture Deficit (inches)		2.65	1.65	0.94
Water Applied (inches)	(a)	2.64	2.64	2.64
	(b)	2.47	2.47	2.47
	(c)	1.32	1.32	1.32
Under-Application (inches)	(a)	0.01	-	-
	(b)	0.18	-	-
	(c)	1.33	0.33	-
Over-Application (inches)	(a)	-	0.99	1.70
	(b)	-	0.82	1.53
	(c)	-	-	0.38

(a) Data based on Hardisty Water Bill Consumption Values.
(b) Data based on number of times lawn watered per month at four gal. of water per minute.
(c) Data based on number of times lawn watered per month at seven gal. of water per minute.

during the 1969 summer season there was an under-application of water for lawn watering for all three smsc values. For the 1970 summer season, there was an under-application of water (0.01 inch) for the three inch smsc value but an over-application of 0.99 inch and 1.70 inches, respectively, for the four and five inch smsc values.

The over-application of water during the summer of 1970 for smsc values of four and five inches may partially be accounted for by the high rates of evapotranspiration, namely, 15.16 inches (four inch smsc) and 15.87 inches (five inch smsc) in comparison with the 1969 summer season rates of evapotranspiration. High monthly amounts of precipitation were recorded in June and July, 1970. Much of this precipitation may not have been available to plants because of rapid runoff from impervious surfaces (i.e., driveways, sidewalks, patios, rooftops) and from the irrigable surface area itself. Thus residents could be of the opinion that lawns and shrubs must be watered in order to compensate for the water lost in a period of rapid runoff. Lawn watering requirements also vary with rooting depth and soil types. For example, there is a slower penetration of water into clay soils than into sandy soils.

The average Hardisty resident waters his lawn ten times a month (responses to questionnaire section E, question three) for a period of one to two hours per day (see

Table 3-4). Assuming a two hour period, the mean number of hours of lawn watering per month is twenty (1,200 minutes). A garden sprinkler will use approximately four to seven gallons per minute at normal domestic pressure depending on the size and length of the service line and the length and size of the sprinkler hose.[15] Thus the average Hardisty resident will use between 4,800 gallons (768 cubic feet) and 8,400 gallons (1,344 cubic feet) of water per month to water a mean irrigable lot area of 5,268 square feet. The mean 1970 summer season water use would be between 3,072 cubic feet and 5,376 cubic feet (assuming a four month summer season). From Table 3-16, the mean number of inches of water utilized for lawn watering would be between 2.47 inches and 1.32 inches. An over-application would occur with the four and five inch smsc values for 2.47 inches of water. For 1.32 inches of water, an over-application would occur only for the five inch smsc value. Therefore, a comparison of the amount of water used for lawn watering as derived from public records and the Hardisty questionnaire shows a very close similarity of results as related to an over-application of water.

Kellow[16], for Calgary, found that lawn watering

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[15] City of Edmonton, Water for Beautiful Edmonton Lawns. Edmonton, n.d., brochure.

[16] R. L. Kellow, A Study of Water Use in Single-Dwelling Residences in the City of Calgary, Alberta. Publication of the Department of Agricultural Economics and Rural Sociology, University of Alberta, Thesis Report 1, Edmonton, May, 1970, p. 85.

increased as lawn areas increased. He equated the amount of water used for lawn watering to the difference between a household's average monthly winter consumption and maximum month consumption. August was the high month of residential consumption and the month when the soil moisture deficit was highest for the year.

From Table 3-17, a comparison of the mean monthly

TABLE 3-17

IRRIGABLE AREA AND WATER CONSUMPTION PER HARDISTY HOUSEHOLD (GALLONS PER MONTH)

Irrigable Area Per Household (Square Feet)	No. of House-holds	No. of House-holds (%)	Mean Monthly Winter Rate per Household	High Month per Household
⩽3,000	1	0.4	2,777	4,688
3,001-5,000	128	47.2	4,911	10,994
5,001-7,000	127	46.9	4,869	10,950
7,001-9,000	10	3.6	4,900	12,306
9,001-11,000	4	1.5	5,839	12,825
>11,000	1	0.4	5,279	13,313

winter rate of water use and the high month (June) water use for Hardisty is shown. For the 1970 summer season, the soil moisture deficit for the month of June was second only to August (see Table 3-15). The large amount of precipitation in July, 1970 may explain why August was not the high month of water use for Hardisty. Like Calgary, as the irrigable

area per Hardisty household increased, lawn watering increased.[17]

3. Assessed house value

From Table 3-18, assessed house value categories and

TABLE 3-18

ASSESSED HOUSE VALUES

Value ($)	No.	%	
3,000-4,000	69	25.4	
4,001-5,000	168	62.0	Mean - 4,390
5,001-6,000	23	8.5	Std.Dev. - 656
6,001-7,000	10	3.7	
>7,000	1	0.4	

Source: Office of the Assessor and Tax Collector, City of Edmonton.

respective numbers and percentages may be found. Assessment is based on three-quarters of the 1957 value of houses--about 45 per cent of the 1970 value. A new assessment base will be in effect by 1973.[18] The mean assessed value was $4,391 (to

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[17] The household with the highest water use is in the 3,001-5,000 square feet irrigable area category. Thus the mean monthly winter rate and high month water use figures for this category are slightly higher than for the 5,001-7,000 square feet category.

[18] The Edmonton Journal, "Assessment rises to $875,999,400". Mar. 11, 1971, p. 12.

the nearest dollar). Sixty-two per cent of the sample had houses assessed between $4,000 and $5,000.

For the City of Edmonton, the number of single family dwelling units as of March, 1970 was 72,795.[19] The taxable assessment on single family dwelling improvements as of January, 1970 was $264,843,190.[20] The mean assessment for single family dwellings for Edmonton in 1970 was $3,624 (to the nearest dollar). This mean assessment figure was derived by dividing the taxable assessment of $264,843,190 by the total number of single family dwellings in Edmonton in 1969, 71,532. Although the taxable assessment figure was released in 1970, it is applicable to the latter months of 1969. Therefore, the mean Hardisty assessment exceeded the mean City of Edmonton assessment for single family dwellings by $767.

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[19] City of Edmonton, Office of the Assessor and Tax Collector. Building and Dwelling Units by Type and by Roll Number Zones, mimeo, Mar. 4, 1970, 1 p.

[20] City of Edmonton, Office of the Assessor and Tax Collector. Distribution of 1970 Taxable and Exempt Rolls, mimeo, Jan. 16, 1970, 1 p.

CHAPTER IV

PRICE AND WATER USE

A. The Effects of Price Increases on Water Use

It is difficult to reliably estimate the response of consumers to various water rates. How great must an increase in water rates be to induce a reduction in water use by residential customers? Lawn watering contributes most significantly to peak hourly and peak daily demands of a water supply system. Such demands will be discussed in Chapter V. The purpose of this section is to outline general improvements which could be made with reference to water rate schedules, and to review the effects of price increases on residential water use as outlined in various studies.

Grima[1] outlines three ways to improve water rate schedules in general. These are, abolish the declining block rate and minimum bill, abolish any demand charges such as meter service charges and increase the marginal price (commodity charge) so as to include a sewer service charge.

With a declining block rate the more water a resident uses, the lower the price. Those who can afford larger

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[1] A. P. Grima, Residential Water Demand: Alternative Choices for Management. Unpublished Ph.D. Thesis, University of Toronto, Toronto, 1970, pp. 201-205 and 207.

amounts of water use more water and contribute to peak demands. It is most likely that the abolition of the declining block rate would reduce water use since from the initial unit of consumption, the consumer would have the incentive to diminish water use. Demand charges (i.e. meter service charges) included in the minimum bill should also be terminated.

An increase in the marginal price of water (commodity charge) may be necessary with the abolition of the minimum bill and declining block rate such that a municipality can realize sufficient revenue; the marginal price should at least equal the average cost. By combining the water supply charge and sewer service charge, the commodity charge for residential water would approximately double. Investment requirements for both the water purification plant and sewage treatment plant would be lowered. For example, if the price is raised from 30 to 60 cents per 1,000 gallons, the investment requirements are reduced by $10.2 million.[2]

Edmonton does combine its water supply and sewer service charges. The monthly minimum bill for Hardisty was $1.72 (inclusive of sewer service charge) for 0 to 2,500 gallons of water. There is a declining block rate schedule. On January 1, 1971, a 10 per cent water price increase was enacted. There was no increase in residential sewer service charges.

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[2] Ibid., Table 4.12, p. 206.

Past studies have indicated both no effect of a water price increase on water consumption and a decline in consumption as prices rise. A study by Howe and Linaweaver[3] provided no data on the duration or relative frequency of extreme (versus marginal) values of residential water use. The price of water did not affect the quantity demanded. Elder[4] reported there was no apparent effect on consumption by a price increase of 18 per cent in Los Angeles in 1938. However, post depression price increases for all commodities caused a diminishing effect of rises in water prices. Flack[5] reported that although Colorado Springs raised its price, the effect on demand was obscured by annual variations in climate, water use restrictions and new housing developments with larger lawns and thus larger sprinkling demands.

Ware and North[6] found that consumers will substantially reduce consumption when monthly water bills are affected by larger increases in water prices. But offsetting such reductions was the finding that as incomes increase, water

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[3] Howe and Linaweaver, op. cit., p. 30.

[4] C. C. Elder, "Determining Future Water Requirements". Journ. A.W.W.A., Feb., 1951, p. 129.

[5] J. E. Flack, "Meeting Future Water Requirements Through Reallocation". Journ. A.W.W.A., Nov., 1967 pp. 1342-1343.

[6] J. E. Ware and R. M. North, "Price and Consumption of Residential Use in Georgia". The Atlanta Economic Review, Oct., 1968, p. 13.

use increases. Gottlieb[7], for studies in Kansas, found an inverse relationship between water rates and consumption levels. Gardner and Schick[8] reported that consumers in municipalities with high water prices purchased less water than consumers in municipalities with low prices.

It appears very doubtful that an all-inclusive methodology can be formulated to forecast residential water demands for urban areas in general. Each area requires a detailed study to determine the costs of supplying additional water and to determine possible water price increases.

B. Hypothetical Price Increases and the Effect on Water Use

The water charge and sewer charge for Edmonton are shown in Table 4-1. The sewer charge is 6 cents per 100 cubic feet (625 imperial gallons). Commencing with the April, 1970 City of Edmonton utility bills, water and sewer charges were separated in order to clearly outline separate charges. If utility accounts are not paid by the due date, a 6 per cent interest penalty is added. The interest charges are calculated only for the first month a bill is overdue, an additional 6 per cent is not added.

For the Hardisty study, questions concerning the price of water were asked in section D of the questionnaire.

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[7] M. Gottlieb, "Urban Domestic Demand for Water: A Kansas Case Study". Land Economics, May, 1963, p. 208.

[8] B. D. Gardner and S. H. Schick, Factors Affecting Consumption of Urban Household Water in Northern Utah. Utah State University, Bulletin 449, Logan, Nov., 1964, p. 14-15.

TABLE 4-1

WATER AND SEWER CHARGES, CITY OF EDMONTON*

Consumption Per Month Imperial Gallons (Cu.Ft.)		Cost in Cents Per 625 Gal. (100 Cu.Ft.) Cost in Cents Per 1,000 Gal. (160 Cu.Ft.) in Parentheses	
		Inclusive of Sewer Service Charge	Exclusive of Sewer Service Charge
First	5,000 (800)	43.0 (68.8)	37.0 (59.2)
Next	20,000 (3,200)	34.3 (54.9)	28.3 (45.3)
Next	21,875 (3,500)	28.2 (45.1)	22.2 (35.5)
Next	109,375 (17,500)	26.8 (42.9)	20.8 (33.3)
Next	2,968,750 (475,000)	22.4 (35.8)	16.4 (26.2)
Next	6,250,000 (1 Mil.)	21.0 (33.6)	15.0 (24.0)
Over	9,375,000 (1.5 Mil.)	17.5 (28.0)	11.5 (18.4)

The minimum monthly charge for consumption from 0-2,500 gallons (0-400 cu.ft.) was $1.72 including sewer service charge and $1.48 excluding sewer service charge.

*As of December 31, 1970. On January 1, 1971 there was a 10 per cent water price increase. There was no increase in sewer service charges for residential customers.

Source: The City of Edmonton, Waterworks Distribution System Tariff. December 4, 1961.

The purpose of such questions was to discover if people thought the price of water was too high, too low or fair, and if they would alter their water consumption in response to hypothetical 10 per cent and 50 per cent rises in price. A topic of importance to Edmonton Water officials, as with all water departments, is the effect of increased water prices

upon the amount of residential water consumption and subsequently the revenues to be gained.

The sample number of residences upon which the findings are based is 271. Concerning the price for water, 240 (88.6 per cent) of the sample (see Table 4-2) thought the price they paid for water was fair. Tables 4-3, 4-4, 4-5 and 4-6 provide data on the responses to hypothetical 10 per cent and 50 per cent increases in the price of water and the residential uses of water. These tables are self-explanatory.

TABLE 4-2

OPINION OF PRICE PAID FOR WATER

Opinion	No.	%
Too High	26	9.6
Too Low	2	0.7
Fair	240	88.6
Did not answer	3	1.1
Total	271	100.0

Source: Questionnaire, Section D, Question 1

Crosstabulations were performed between numerous variables and the responses to hypothetical 10 per cent and 50 per cent increases in the price of water for each use category (see questionnaire: section D, question 3). The chi-squared test was used to test the significance of the variables being crosstatulated. The chi-squared method

TABLE 4-3

A HYPOTHETICAL 10 PER CENT AND 50 PER CENT INCREASE IN THE PRICE PAID FOR WATER--USE LESS WATER

Use Less Water					
10% Rise in Price			50% Rise in Price		
Opinion	No.	%	Opinion	No.	%
Yes	56	20.7	Yes	201	74.2
No	211	77.8	No	59	21.8
Did not respond	4	1.5	Did not respond	11	4.1
Total	271	100.0	Total	271	100.0

Source: Questionnaire, Section D, Question 3a)

TABLE 4-4

A HYPOTHETICAL 10 PER CENT AND 50 PER CENT INCREASE IN THE PRICE PAID FOR WATER--USE LESS WATER FOR DOMESTIC PURPOSES

Use Less Water for Domestic Purposes					
10% Rise in Price			50% Rise in Price		
Opinion	No.	%	Opinion	No.	%
Yes	23	8.5	Yes	96	35.4
No	244	90.0	No	164	60.5
Did not respond	4	1.5	Did not respond	11	4.1
Total	271	100.0	Total	271	100.0

Source: Questionnaire, Section D, Question 3b)

TABLE 4-5

A HYPOTHETICAL 10 PER CENT AND 50 PER CENT INCREASE IN THE PRICE PAID FOR WATER--USE LESS WATER FOR LAWNS, SHRUBS, PLANTS

Use Less Water for Lawns, Shrubs, Plants					
10% Rise in Price			50% Rise in Price		
Opinion	No.	%	Opinion	No.	%
Yes	56	20.7	Yes	199	73.4
No	211	77.8	No	61	22.5
Did not respond	4	1.5	Did not respond	11	4.1
Total	271	100.0	Total	271	100.0

Source: Questionnaire, Section D, Question 3c)

TABLE 4-6

A HYPOTHETICAL 10 PER CENT AND 50 PER CENT INCREASE IN THE PRICE PAID FOR WATER--USE THE SAME AMOUNT OF WATER

Use the Same Amount of Water					
10% Rise in Price			50% Rise in Price		
Opinion	No.	%	Opinion	No.	%
Yes	208	76.7	Yes	57	21.0
No	59	21.8	No	203	74.9
Did not respond	4	1.5	Did not respond	11	4.1
Total	271	100.0	Total	271	100.0

Source: Questionnaire, Section D, Question 3d)

can accept nominal, ordinal or interval data and provide a meaningful measure of statistical significance. The questionnaire responses can be tested to see if observed frequencies differ significantly from expected frequencies. Therefore, the chi-squared test provides a weeding-out process whereupon pairs of variables which, by this statistical method are shown to be significant, can receive further inquiry. The variables and respective numbers are as follows.

Variable 1 - a 10 per cent rise in price, use less water.

2 - a 10 per cent rise in price, use less water for domestic purposes.

3 - a 10 per cent rise in price, use less water for lawns and shrubs.

4 - a 10 per cent rise in price, use the same amount of water.

5 - a 50 per cent rise in price, use less water.

6 - a 50 per cent rise in price, use less water for domestic purposes.

7 - a 50 per cent rise in price, use less water for lawns and shrubs.

8 - a 50 per cent rise in price, use the same amount of water.

9 - price paid for water.

10 - the number of persons per household.

11 - family income.

12 - years of education of highest money earner of the household.

13 - other kinds of schooling.

14 - occupation.

Variable 15 - irrigable area.

16 - number of rooms per household.

17 - assessed value of house.

18 - date house built.

19 - automatic clothes washer.

20 - clothes washer (wringer type).

21 - automatic dish washer.

22 - food waste (garbage) disposal unit.

23 - toilet.

24 - shower.

25 - bathtub.

26 - shower/bathtub combination.

27 - bathroom sink.

28 - single kitchen sink.

29 - double kitchen sink.

30 - single laundry tub.

31 - double laundry tub.

32 - water-cooled air conditioner.

33 - furnace humidifier.

34 - portable humidifier.

35 - refrigerator with automatic ice-making device.

Crosstabulations were performed between each of variables one to eight and variables nine to thirty-five. Chi-squared values were obtained with the appropriate degrees of freedom. Of the 216 crosstabulations performed forty-three yielded probabilities between 5.0 per cent and 0.1 per cent.

There is between 5.0 and 0.1 per cent probability that the null hypotheses (H_o) are correct. Thus there is between 95.0 and 99.9 per cent probability that the inverse of the null hypotheses (H_1) is correct. Fifteen crosstabulations yielded probabilities between 95.0 and 99.9 per cent. Thus there is between 95.0 and 99.9 per cent probability that the observed conditions are a reflection of the expected conditions. Table 4-7 provides a summary of the fifty-eight crosstabulations. Section A lists the forty-three crosstabulations with probabilities between 5.0 and 0.1 per cent. Section B lists the fifteen crosstabulations with probabilities between 95.0 and 99.9 per cent.

C. Comments on the Hardisty Crosstabulations

The purpose of Table 4-7 is to show which variables are highly significant when crosstabulated with variables showing hypothetical increases in the price paid for water and associated water uses.

In order to illustrate how Table 4-7 should be interpreted, the following explanation is given. Taking the first crosstabulation in Section A, the variables crosstabulated are variable one (a 10 per cent rise in price, use less water) and variable nine (price paid for water--high, low, fair). The H_o may be stated that there is a relationship between a 10 per cent rise in price, use less water, and the price paid for water. The chi-squared value of 19.69 with two degrees of freedom indicates a probability of 0.1 per

cent that the correlation established is correct; that there is 0.1 per cent probability that the H_o is correct. Therefore, there is a 99.9 per cent probability that the H_1 is correct, i.e., that there is a minute relationship between a 10 per cent rise in price, use less water, and the price paid for water. In other words, the percentage probability is very small that there is a relationship between using less water with a 10 per cent price increase as associated with the customer's opinion of the price he pays for water. The validity of the H_1 is supported by 20.7 per cent of the respondents answering yes to variable one. Thus 79.3 per cent of the respondents answered no; they would not use less water with a 10 per cent increase in price.

Referring to the last two columns of Table 4-7, Section A, the second to last column indicates that 266 of the 271 respondents gave an opinion to the price they pay for water. The last column is not applicable to variable nine.

Concerning the crosstabulation of variables one to eight with variables nineteen to thirty-five (household water appliances and plumbing fixtures), an important consideration is the number of households which do not have a particular appliance or fixture. As seen in Table 4-7, Section A (last column), each of variables twenty, twenty-eight, thirty and thirty-four were not present in over 200 of the sample of 271 households. The paucity of these items should be kept in mind when reviewing Section A. Likewise in Section B

(last column) of Table 4-7, the crosstabulation probabilities of variables twenty-two, twenty-four, twenty-nine and thirty-one must be viewed with respect to the number of households without these items.

In addition to the appliance and fixture variables mentioned, the only other variable which involves a small portion of the sample is variable thirteen, other kinds of schooling. This portion is 66 of 271 (see Section A).

D. Analysis of Table 4-7

The purpose of Table 4-7 is to show which variables are significant (by using the chi-squared test) when crosstabulated with various hypothetical price increases and water uses. No other examples of the relationship between hypothetical price increases and variables affecting residential water use were found in the residential water use literature. Thus the findings contained in Table 4-7 are an initial attempt to illustrate the aforesaid relationship.

Two examples of the interesting relationships resulting from the crosstabulations are as follows. Variable eleven (family income) is not contained in the Table; hypothetical price increases are not shown to be significant when crosstabulated with family income. One might expect that families with high incomes would not use less water even with a 50 per cent increase in price. Thus a continuance of present water consumption levels, with such a price increase,

TABLE 4-7

Section A

CROSSTABULATION PROBABILITIES BETWEEN
5.0 PER CENT AND 0.1 PER CENT

Variables Crosstabulated	Chi-Squared Value	Degrees of Freedom	Probability of Correlation Established (%)	% of Respondents Answering Yes to First Variable Crosstabulated	Number of Sample (271) Who Answered Second Variable Crosstabulated	Number of Sample (271) Who Do Not Have Second Variable Crosstabulated
1,9	19.69	2	0.1	20.7	266	N/A
3,9	24.41	2	0.1	20.7	266	"
1,12	18.41	5	0.5	20.8	250	"
2,12	11.50	5	5.0	8.8	250	"
3,12	16.70	5	1.0	20.8	250	"
4,12	19.03	5	0.5	78.0	250	"
5,13	24.34	7	0.1	83.3	66	"
6,13	15.60	7	5.0	43.9	66	"
7,13	21.83	7	0.5	80.3	66	"
8,13	24.34	7	0.1	16.7	66	"
1,14	23.21	4	0.1	20.9	253	"
5,14	11.88	4	2.5	77.7	247	"
2,14	10.98	4	5.0	8.7	253	"
6,14	13.18	4	2.5	37.2	247	"
3,14	22.57	4	0.1	20.9	253	"
7,14	14.04	4	1.0	76.9	247	"
4,14	23.40	4	0.1	77.9	253	"
8,14	13.70	4	1.0	21.5	247	"
2,17	17.28	8	5.0	8.6	267	"

continued...

TABLE 4-7 continued

Section A

Variables Crosstabulated	Chi-Squared Value	Degrees of Freedom	Probability of Correlation Established (%)	% of Sample Who Have 2nd Variable and answered Yes to 1st Variable Cross-tabulated	Number of Sample (271) Who Answered Second Variable Crosstabulated	Number of Sample (271) Who Do Not Have Second Variable Crosstabulated
5,20	11.60	4	2.5	75.0	N/A	229
6,20	10.91	4	5.0	36.1	"	229
7,20	11.52	4	2.5	75.0	"	229
8,20	11.71	4	2.5	25.0	"	229
2,23	16.38	6	2.5	8.6	"	0
1,27	38.95	8	0.1	21.0	"	6
5,27	20.18	8	1.0	23.0	"	6
2,27	38.99	8	0.1	8.8	"	6
6,27	18.47	8	2.5	37.8	"	6
3,27	38.53	8	0.1	21.0	"	6
7,27	19.59	8	2.5	23.8	"	6
4,27	38.26	8	0.1	77.9	"	6
8,27	18.83	8	2.5	22.1	"	6
6,28	10.15	4	5.0	29.8	"	207
2,30	11.81	4	2.5	22.9	"	236
6,30	11.00	4	5.0	38.2	"	236
1,34	80.20	4	0.1	4.8	"	247
5,34	33.48	4	0.1	70.0	"	247
2,34	77.34	4	0.1	4.8	"	247
6,34	33.30	4	0.1	30.0	"	247
3,34	80.20	4	0.1	4.8	"	247
7,34	33.35	4	0.1	70.0	"	247
4,34	80.54	4	0.1	95.2	"	247
8,34	32.98	4	0.1	25.0	"	247

TABLE 4-7

Section B

CROSSTABULATION PROBABILITIES BETWEEN
95.0 PER CENT AND 99.9 PER CENT

Variables Crosstabulated	Chi-Squared Value	Degrees of Freedom	Relevant Probability is > (%) (Observed Conditions Reflect Expected Ones)	% of Respondents Answering Yes to First Variable Crosstabulated	Number of Sample Who Answered Second Variable Crosstabulated	Number of Sample Who Do Not Have Second Variable Crosstabulated
5,10	2.61	9	97.5	77.9	258	N/A
8,10	2.81	9	95.0	21.3	258	"
3,15	2.71	10	97.5	20.6	267	"
3,16	4.92	12	95.0	20.6	267	"
2,18	4.15	16	99.5	8.6	267	"
6,18	4.67	16	99.5	37.2	261	"
5,18	5.10	16	99.5	77.3	261	"
7,18	6.00	16	97.5	76.6	261	"
8,18	5.17	16	99.0	21.8	261	"

				% of Sample Who Have 2nd Variable and Answered Yes to 1st Variable Crosstabulated		
2,22	0.58	4	95.0	8.8	N/A	178
7,22	0.51	4	95.0	77.8	"	178
2,24	0.44	4	97.5	9.4	"	152
3,29	0.36	4	97.5	20.9	"	58
4,29	0.53	4	95.0	22.4	"	58
7,31	0.66	4	95.0	75.0	"	229

would be shown as being significant. Perhaps the number of families above the modal family income range of $7,001 to $10,000 was not large enough to indicate a high level of significance. The crosstabulation of variable fifteen (lawn area) is significant only with a 10 per cent increase in price, use less water for lawns and shrubs. The majority of respondents said they would not use less water for lawn watering with such a 10 per cent price increase. Thus lawn area is significant in reinforcing the opinion of respondents that they would not reduce lawn watering with a 10 per cent price increase. It would be expected that variable seven (a 50 per cent increase in price, use less water for lawns and shrubs) and lawn area would have a significant cross-tabulated value since 73.4 per cent of respondents indicated that they would reduce lawn watering with a 50 per cent price increase. Additional information on the two variables cross-tabulated is required in order to explain why a high level of significance was not attained.

The data contained in Table 4-7 pose many questions as to why certain crosstabulations, such as lawn area and a 50 per cent price increase use less water for lawns and shrubs, do not have high levels of significance. It is difficult to analyse the results of this Table since such results are an initial attempt to provide some insight into the relevance of hypothetical price increases. The relationships must first be tested in other study areas, and then

compared with the Hardisty findings, before a reliable decision can be made as to the applicability and predictability of chi-squared significance levels in assessing such results as found in Table 4-7. Hopefully, other researchers will test hypothetical price increases and the effects of such increases on residential water use in other study areas.

E. Concluding Recommendations

Studies are lacking in which hypothetical price increases for various water uses are outlined and in which questionnaire respondents are asked to indicate their reactions to such increases. Questionnaire question three, section D, was asked so as to provide data on hypothetical price increases for residences within the single community of Hardisty. Such a question could also be of value in inter-community water use studies.

With reference to the Hardisty crosstabulations, the query arises, how can responses to hypothetical price increases be accurately measured? Are such responses a true reflection of how people would react if the proposed price increases were implemented, or are the responses made in a 'vacuum' without consideration of other relevant variables? These queries are difficult to answer. But a comparison study of water use as related to a change in water rates is now possible in Edmonton because of the 10 per cent increase in the water rates effective January 1, 1971. For example,

it would be interesting to tabulate the water consumption of the 271 Hardisty respondents throughout 1971 to see if there was any reduction in the amount of water consumed in relation to the 10 per cent price increase. A random sample of single family dwellings for the entire city would also be a possible area of investigation concerning the water use--new water price relationship.

Each city must conduct an individual detailed study to determine the relationships of water supply costs and water rates. Factors such as climate, land use codes, water rate structures, treatment costs, number of customers, etc., vary among cities. Individual water departments must devise methodologies which will accurately measure the water consumer's reaction to price increases. Such a methodology is outside the scope of this study.

As previously outlined, studies have been conducted which indicated both no effect of a water price increase on water consumption and also a decline in consumption as prices rise. A study of interest was that conducted by Hanke in 1969 in Boulder, Colorado.[9] The city had been completely metered in 1961 and 180 customers were interviewed (stratified random sample) in 1969 to discover the effect on residential consumption of the water price increase associated with

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[9]S. H. Hanke, "Some Behavioral Characteristics Associated with Residential Water Price Changes". Water Resources Research, Oct., 1970, pp. 1383-1386.

metering. Of the sample, 68 per cent said they were more concerned about water use after metering and that they made substitutions for water.

Of interest and value is how the conservation practices changed over time. After the first year of metering, 51 per cent of the sample indicated that they had intensified conservation practices. Only 1.7 per cent discontinued these practices and 47.3 per cent said they did not know what they had done. The results of these personal interviews were validated by empirical trend analyses. The results of the Boulder study conform to the conventional economic theory that price elasticities increase with time since consumers can adjust to price changes. Over time, substitutions are made resulting in a more efficient use of water and an increase in conservation practices.

For Calgary, Kellow[10] did not examine the effect of price on residential water use. He did discover that although flat rate customers used nearly twice the amount of water as metered customers, the average revenue from both customers was practically identical ($51.95 flat rate and $52.00 metered). Households with a large number of assessment items (number or rooms, taps, basins, etc.) preferred metering. A study should be made of the pricing policies of Calgary as related to water use.

The results from Hanke's study are far from conclusive.

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[10]Kellow, op. cit., p. 126.

But following the installation of meters both domestic and sprinkling rates of water consumption have remained at lower levels. Additional studies are required of a consumer's behavioural and water use adjustments associated with changes in water prices. Such studies will enable water managers to implement more efficient pricing systems.

CHAPTER V

HARDISTY WATER USE: ANALYSIS

A. Daily Water Use

Daily water use for the sampled residences is summarized in Table 5-1. The method of calculation for each questionnaire was to divide the total water consumption from June, 1969 to August, 1970 by 457--the number of days in this fifteen month period. Four categories with 150 gallon

TABLE 5-1

DAILY WATER USE FOR HARDISTY RESIDENCES[1]

Daily Gallonage	No.	%
50 - 200	101	37.3
201 - 350	152	56.0
351 - 500	17	6.3
501 - 650	1	0.4

Mean - 231.34
Std.Dev. - 78.53
Minimum - 57.64
Maximum -616.25

[1]Period of study includes two summers.

Source: Edmonton Utilities Records

intervals were established. The mean number of gallons per capita per day (gpcd) of water use for Hardisy was 52.8 (the mean number of persons per household being 4.38).

For the purpose of comparison, the following gpcd and gallons per day (gpd) figures are provided. Saville[1] (over fifty years ago) found that the average single-dwelling water use varied from 8 to 91 gpcd with an average demand approximating 29 gpcd. MacKichan[2] studied the upper Mississippi River Basin above the Ohio River and found the average use to be 123 gpcd. Larson and Hudson[3], in a study of fifteen Illinois cities found the residential water use ranged from 18 to 44 gpcd. Learned[4] in a study of Kansas City households discovered that 50 per cent used under 83 gpd and 73 per cent used under 139 gpd.

A study in Boulder, Colorado, conducted by Hanke and Flack[5] showed 1964 (a dry year) and 1965 (a wet year) water use to be 143 gpcd and 125 gpcd, respectively. One hundred per cent of Boulder was metered. Ware and North[6], in a study of 634 households within thirteen Georgia cities, found

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[1]C. M. Saville, "What is the Legitimate Use of Water?". Journ. A.W.W.A., Dec., 1920.

[2]K. A. MacKichan, "Estimated Use of Water in the United States, 1955". U. S. Geological Survey Circular, No. 398, 1957, p. 3.

[3]B. O. Larson and H. E. Hudson, Jr., "Residential Water Use and Family Income". Journ. A.W.W.A., Aug., 1951, p. 610.

[4]A. P. Learned, "Determination of Municipal Water Rates". Journ. A.W.W.A., Feb., 1957, p. 171.

[5]S. H. Hanke and J. E. Flack, "Effects of Metering Urban Water". Journ. A.W.W.A., Dec., 1968, p. 1364.

[6]Ware and North, op. cit., p. 12.

the mean water use to be 47 gpcd. Two studies in direct contrast to Ware's and North's findings, and also to Hardisty findings, are Gardner's and Schick's[7] figure in forty-three Utah communities of 204 gpcd and the national U.S.A. water use study of Howe and Linaweaver[8] which showed 108 gpcd. Ware and North found that price differences between communities helped to explain these per capita water use differences.

Studies have also been conducted in Canada. Kellow[9], for the City of Calgary in 1968, found that water use for metered households was 68 gpcd and 247 gpd per dwelling unit. In Ontario, Watt[10] allowed 50-60 gpcd for residential areas. For the Windsor area, 1937 and 1957 consumption rates were 52 and 54 gpcd, respectively.[11] Grima sampled ninety-one residences in five municipalities in the Metropolitan Toronto and Region Transportation Study area. The mean annual water use was 143 gpd per dwelling unit.[12]

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[7]Gardner and Schick, op. cit., pp.8-9.

[8]Howe and Linaweaver, op. cit., p. 18.

[9]Kellow, op. cit., p. 73.

[10]A. K. Watt, "Adequacy of Ontario's Water Resources". The Canadian Mining and Metallurgical Bulletin, Aug., 1967, p. 920.

[11]Ontario, Ontario Water Resources Commission, Report on Water Resources Survey, County of Kent. Toronto, Oct., 1958, p. 15.

[12]Grima, op. cit., pp. 117 and 127.

Peak hourly demands per dwelling unit per day may also be derived. Table 5-2 shows daily, maximum day and peak hour means in gpd per dwelling unit for Edmonton and the Johns Hopkins Study.

TABLE 5-2

COMPARISON OF CITY OF EDMONTON WATER USE AND THE JOHNS HOPKINS RESIDENTIAL WATER USE STUDY[1] RESULTS

	City of Edmonton (1969 Figures)[2]	Johns Hopkins Study		
		U.S. National Average	West M. & P.S.	East M. & P.S.
	Imperial Gallons Per Day Per Dwelling Unit			
Daily Average	320[3]	324	382	258
Maximum Day Average	584	724	816	655
Peak Hour Average	1,003	1,762	2,067	1,527

Note: M. & P.S. stands for Metered and Public Sewers

[1]Source: F. P. Linaweaver, Jr., J. C. Geyer and J. B. Wolff, op. cit., pp. 269-278.

[2]Number of Dwelling Units in 1969 - 119,961
Population in 1969 - - 422,418
Average No. of Persons Per Dwelling Unit - - 3.52

[3]See Table 1-2 for mean yearly demand - 90.8 gpcd
90.8 times 3.52 (Persons per dwelling unit) = 320 gpd per du

For all water uses in Edmonton--residential, commercial and industrial and suburban--the peak hourly demand in 1969 was between 8 and 9 P.M. on June 16th; namely, 74,594

million gallons. In 1970, the peak hour demand was between 8 and 9 P.M. on June 3rd; namely, 77,279 million gallons.[13] As previously mentioned, Edmonton Water plans to monitor Hardisty in 1971 in order to secure readings of the peak hour and peak day water flows. Such information will aid Edmonton Water planners in predicting future water requirements of residential developments to be located in Metropolitan Edmonton.

This outline of daily and peak hour water demands for Hardisty and other areas in North America indicates the large range of water use as expressed in gpcd and gpd per dwelling unit. Many variables, as described in Chapter III contribute to these variations. An analysis of these factors as related to Hardisty residential water use and a comparison of Hardisty trends with the findings of other water use studies will be made. But preceding an analysis of Chapter III variables, annual and monthly and seasonal water uses in Hardisty will be compared with such uses in other areas.

B. Annual and Monthly Water Use

The mean annual and monthly water use in Hardisty was 84,576 and 7,048 gallons per dwelling unit (gpdu), respectively. This compares with Ware's and North's[14] findings of mean annual and mean monthly values of 66,167 and 5,514

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[13] Edmonton Water records.

[14] Ware and North, op. cit., p. 11.

gpdu, respectively. Howe and Linaweaver[15] found a mean annual water use of 68,742 gpdu and a mean monthly water use of 5,729 gpdu. Dunn's and Larson's[16] mean annual and monthly values were 45,020 and 3,752 gpdu, respectively, for 208 single-dwelling units in Kankakee, Illinois. Grima[17] for the Metropolitan Toronto area study found a mean annual value of 52,195 gpdu and a mean monthly value of 4,290 gpdu.[18]

As mentioned in Chapter IV, the chi-squared test is a statistical test which provides a meaningful measure of statistical significance. Crosstabulated variables which are shown to be highly significant through the use of chi-square can receive further inquiry. For Hardisty data, crosstabulations were performed between the mean number of gallons of water used by Hardisty residences per month between June, 1969 and August, 1970 (Variable 36) and the following variables. Chi-squared values and appropriate degrees of freedom are in parentheses.

a) Variable 10 - number of persons per household (79.22 with 30 degrees of freedom).

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[15] Howe and Linaweaver, op. cit., p. 18.

[16] D. F. Dunn and T. E. Larson, "Relationship of Domestic Water Use to Assessed Valuation, With Selected Demographic and Socio-economic Variables". Journ. A.W.W.A., Apr., 1963, p. 448.

[17] Grima, op. cit., p. 123.

[18] The mean annual and monthly gpdu figures are derived by taking the mean figure of 143 gpd per dwelling unit and multiplying it by 365 and 30, respectively.

b) Variable 11 - total annual family income (69.14 with 27 degrees of freedom).

c) Variable 16 - number of rooms per household (65.92 with 18 degrees of freedom).

and d) Variable 17 - assessed value of house (17.78 with 12 degrees of freedom).

Only variable seventeen yielded a probability of less than 99.9 per cent. Therefore, there is a greater than 99.9 per cent probability that the observed conditions are a reflection of the expected conditions with respect to the mean number of gallons of water used per residence per month from June, 1969 to August, 1970 and each of variables ten, eleven, sixteen and seventeen.

Tables 5-3, 5-4, 5-5 and 5-6 provide information on water use (variable thirty-six) and variables ten, eleven, sixteen and seventeen, respectively. The purpose of these tables is to show how water use varies between the 271 sampled Hardisty residences depending upon certain variables. The highest mean number of gallons of water used per household between June, 1969 and August, 1970 for each table follows an expected trend, namely, the highest mean water use is equated to the households with the greatest number of people, highest incomes, greatest number of rooms and highest assessment.

With reference to Table 5-3, the greater the number of persons per household the greater should be the mean household water use. The exceptions are that houses with

TABLE 5-3

WATER USE AND NUMBER OF PERSONS PER HOUSEHOLD (VARIABLE 10)

Variable 10	No. of Households	No. of Households (%)	Total No. Gal. June, 1969 to Aug. 1970	Mean No. Gal. Per Household June,1969 to Aug.1970
Did not respond	3	1.1	274,638	91,546
1	3	1.1	266,138	88,713
2	28	10.3	2,229,732	79,633
3	36	13.3	3,089,839	85,829
4	82	30.3	8,729,588	106,458
5	63	23.2	6,794,989	107,857
6	27	10.0	3,125,025	115,742
7	17	6.3	2,166,922	127,466
8	7	2.6	1,159,133	165,590
9	2	0.7	249,126	124,563
10	3	1.1	565,950	188,650
Total	271	100.0	28,651,080	105,724

TABLE 5-4

WATER USE AND FAMILY INCOME (VARIABLE 11)

Variable 11 ($)	No. of Households	No. of Households (%)	Total No. Gal. June, 1969 to Aug. 1970	Mean No. Gal. Per Household June,1969 to Aug.1970
Did not respond	32	11.8	3,259,638	101,864
<3,000	4	1.5	317,451	79,363
3,001-5,000	7	2.6	616,583	88,083
5,001-7,000	15	5.5	1,271,410	84,761
7,001-10,000	78	28.8	7,844,337	100,568
10,001-12,500	49	18.1	5,490,778	112,057
12,501-15,000	43	15.9	4,825,167	112,213
15,001-17,500	15	5.5	1,550,640	103,376
17,501-20,000	16	5.9	1,849,211	115,576
>20,000	12	4.4	1,625,865	135,489
Total	271	100.0	28,651,080	105,724

TABLE 5-5

WATER USE AND NUMBER OF ROOMS PER HOUSEHOLD (VARIABLE 16)

Variable 16	No. of Households	No. of Households (%)	Total No. Gal. June, 1969 to Aug. 1970	Mean No. Gal. Per Household June,1969 to Aug.1970
4	2	0.7	155,688	77,844
5	73	27.0	7,065,136	96,783
6	70	25.8	7,275,892	103,941
7	80	29.5	8,388,381	104,855
8	25	9.2	3,078,678	123,147
9	16	6.0	1,865,748	116,609
10	5	1.8	821,557	164,311
Total	271	100.0	28,651,080	105,724

TABLE 5-6

WATER USE AND ASSESSED HOUSE VALUE (VARIABLE 17)

Variable 17 ($)	No. of Households	No. of Households (%)	Total No. Gal. June, 1969 to Aug. 1970	Mean No. Gal. Per Household June,1969 to Aug.1970
3,000-4,000	69	25.4	6,859,039	99,406
4,001-5,000	168	62.0	17,858,198	106,299
5,001-6,000	23	8.5	2,523,190	109,704
6,001-7,000	10	3.7	1,278,590	127,859
>7,000	1	0.4	132,063	132,063
Total	271	100.0	28,651,080	105,724

one person have a mean water use greater than houses with two or three persons. Also, houses with nine persons have a mean water use less than houses with seven persons. It is difficult to draw conclusions from these exceptions because of the small number of households with one and nine persons, namely, three and two, respectively.

From Table 5-4, households with earnings between $5,001 and $7,000 have a mean water use less than households with earnings between $3,001 and $5,000. Also, households with earnings between $15,001 and $17,500 have a mean water use less than households with earnings between $10,001 and $12,500.

From Table 5-5, houses with nine rooms have a lower mean water use than houses with eight rooms.

It is difficult to account for these discrepancies. Such discrepancies may be the result of a small sample as with the number of households containing one and nine persons. A more detailed study of individual household water use patterns would be required in order to find an explanation.

Table 5-7 is provided as an attempt to show monthly variations in water use within six specified water use categories for the 271 Hardisty residences comprising this study. The total number of households is not 271 for each month since in certain months negative gallonages exist for some households. The negative quantities result as follows. If a City of Edmonton meter reader cannot gain access to a

TABLE 5-7

MONTHLY WATER USE (IMPERIAL GALLONS) JUNE, 1969 - AUGUST, 1970

Month and Year	≤2,500		2,501-8,000		8,001-13,500		13,501-19,000		19,001-24,500		24,501-30,000		Total	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
June'69	7	2.6	125	46.1	91	33.6	36	13.3	8	2.9	4	1.5	271	100.0
July	5	1.8	59	21.8	118	43.5	56	20.7	23	8.5	10	3.7	271	100.0
Aug.	6	2.2	130	48.0	103	38.0	19	7.0	8	3.0	5	1.8	271	100.0
Sept.	27	10.0	160	59.0	59	21.7	14	5.2	1	0.4	1	0.4	262	96.7
Oct.	33	12.2	195	71.9	27	10.0	2	0.7	1	0.4	0	0.0	258	95.2
Nov.	28	10.3	217	80.0	14	5.2	0	0.0	1	0.4	0	0.0	260	95.9
Dec.	18	6.6	220	81.0	28	10.2	2	0.7	1	0.4	0	0.0	268	98.9
Jan.'70	16	5.9	212	78.2	34	12.6	4	1.5	0	0.0	0	0.0	266	98.2
Feb.	29	10.7	223	82.3	17	6.3	2	0.7	0	0.0	0	0.0	271	100.0
Mar.	26	9.6	226	83.4	16	5.9	1	0.4	0	0.0	0	0.0	269	99.3
Apr.	32	11.8	215	79.4	21	7.7	1	0.4	0	0.0	0	0.0	269	99.3
May	9	3.3	187	69.0	66	24.3	4	1.5	4	1.5	1	0.4	271	100.0
June	2	0.7	77	28.4	123	45.4	51	18.8	11	4.1	7	2.6	271	100.0
July	3	1.1	102	37.6	122	45.0	30	11.1	8	3.0	5	1.8	270	99.6
Aug.	18	6.6	161	59.4	75	27.7	9	3.3	4	1.5	1	0.4	268	98.9

Source: Edmonton Utilities Records

house in a particular month (meters are read monthly), an estimate of the number of gallons of water used (an average of the past several months consumption) is entered as the monthly consumption figure. The average consumption figure (the estimate) may exceed the actual consumption figure whereupon a negative value results. Negative figures are common in September, October and November because people are frequently away from home in July and August resulting in estimates of water consumption having been made. Table 5-8 outlines the months and appropriate categories of negative water consumption.[19]

The mean monthly water use per Hardisty household was 7,048 gallons. This mean figure is contained in the 2,501-8,000 gallon category of Table 5-7. For every month except July, 1969 and June and July, 1970, this category had the greatest number of Hardisty households. Some explanation as to the anomaly of July, 1969 and June and July, 1970 may be found in Table 3-15 and subsequent analyses.

C. Annual, Monthly and Daily Water Costs Per Household

The mean annual Hardisty water cost was $46.08. The mean monthly water bill (June, 1969 to August, 1970) was $3.84. The minimum monthly water use bill was $1.48, exclusive of the sewer service charge (the minimum bill in

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[19]Personal communication with Edmonton Utilities with regard to negative gallonage is the basis of this explanation.

TABLE 5-8

NEGATIVE WATER USE VALUES (IMPERIAL GALLONS) FOR DESIGNATED MONTHS

Month and Year	0 to -2,500		-2,501 to -8,000		-8,001 to -13,500		-13,501 to -19,000		-19,001 to -24,500		Total Negative	Total Negative
	No.	%	No	%	No.	%	No.	%	No.	%	No.	%
Sept.'69	6	2.2	2	0.7			1	0.4			9	3.3
Oct.	5	1.8	4	1.5	4	1.5					13	4.8
Nov.	4	1.5	4	1.5	1	0.4	2	0.7			11	4.1
Dec.	1	0.4	2	0.7							3	1.1
Jan.'70	3	1.0	1	0.4					1	0.4	5	1.8
Mar.	2	0.7									2	0.7
Apr.	1	0.4			1	0.4					2	0.7
July			1	0.4							1	0.4
Aug.	2	0.7	1	0.4							3	1.1

Source: Edmonton Utilities Records

accordance with the minimum number of 2,500 gallons). The minimum monthly bill inclusive of the sewer service charge was $1.72. The maximum Hardisty monthly bill was $9.16. The mean daily cost of water for the fifteen month period was 13 cents. The minimum and maximum daily costs were 5 cents and 30 cents, respectively.

Edmonton has a water rate schedule with declining block rates. From Grima[20], for the town of Barrie and the Toronto borough of North York, which have declining block rate schedules, the minimum annual bill was $24.00 (Barrie) and $13.20 (North York). Edmonton's annual minimum water bill was $17.76 (exclusive of sewer service charge). The annual amounts of domestic water used were 24,000 gallons (Barrie), 60,000 (North York) and 30,000 gallons (Edmonton).

The average cost of water in Metropolitan Toronto in 1967 was 34 cents per 1,000 gallons (included metered and unmetered municipalities).[21] The cost in Hardisty was 59 cents per 1,000 gallons. The average price per 1,000 gallons in Utah municipalities was 17 cents as studied by Gardner and Schick.[22] Ware and North[23], in a Georgia study, found an average water price of $1.00 per 1,000 gallons and a mean

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[20]Grima, op. cit., p. 170

[21]Ibid., p. 201.

[22]Gardner and Schick, op. cit., pp. 8-9.

[23]Ware and North, op. cit., p. 11.

annual bill of $54.54. Howe and Linaweaver[24] reported a mean price of 44 cents per 1,000 gallons.

The high price for water in Edmonton can be attributed to several factors.[25] There are increasing expenditures for wages and high maintenance costs to repair breaks and leaks in the water distribution system. New water lines have to be dug deeper than in most other cities to avoid frost penetration. An increase in the number of suburban customers (Fort Saskatchewan and Redwater in 1970) increases the service area and the number of miles of water lines to be constructed and maintained. A greater number of customers also necessitates a larger Customer Service Division budget to conduct surveys, building checks and customer account checks. Computerization of accounts and monthly meter readings likely increase costs.

Edmonton Water anticipates a yearly increase in revenue of 5 to 6 per cent based primarily on water sales, water frontage taxes and hydrant rentals. A yearly profit is realized. In 1969, a profit of $2,111,479 was realized of which approximately 99 per cent was allocated to the City of Edmonton general revenue and 1 per cent is reserved for water plant extension.

The low Utah price can likely be attributed to an

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[24] Howe and Linaweaver, op. cit., p. 18.

[25] Edmonton Water Annual Report 1969. Edmonton, 1970 pp. 3 and 8.

irrigation subsidy. The service area of Edmonton Water necessitates a water price sufficient to cover costs of future additions to the water distribution system and to provide satisfactory service to customers.

D. Seasonal Water Use

The fifteen months for which water bill and water consumption data were gathered may be divided into the following time periods: June to September, 1969; October, 1969 to April, 1970; May to August, 1970; and June, 1969 to August, 1970. The first three periods will be designated summer, winter and summer seasons as outlined in Table 5-9.

TABLE 5-9

SEASONAL WATER CONSUMPTION FOR HARDISTY, JUNE, 1969 TO AUGUST, 1970

		Summer Season 1969 June,1969 to Sept.,1969	Winter Season 1969-70 Oct.,1969 to Apr.,1970	Summer Season 1970 May,1970 to Aug.,1970	Fifteen Month Period June,1969 to Aug.,1970
Total Consumption	Mean	36,600	34,285	34,837	105,720
	Std.Dev.	14,446	14,364	12,892	35,893
Monthly Consumption	Mean	9,150	4,898	8,709	7,048
	Std.Dev.	3,612	2,052	3,223	2,393
Summer Season Exceeds Winter Season	Gal.	4,252		3,811	
	%	86.8		77.8	

Source: Edmonton Utilities Records

The seasonal water costs to Hardisty residents are outlined in Table 5-10.

TABLE 5-10

SEASONAL WATER COSTS TO HARDISTY RESIDENTS, JUNE, 1969 TO AUGUST, 1970 ($ and ¢)

		Summer Season 1969 June,1969 to Sept.,1969	Winter Season 1969-70 Oct.,1969 to Apr.,1970	Summer Season 1970 May,1970 to Aug.,1970	Fifteen Month Period June,1969 to Aug.,1970
Total Cost	Mean	19.24	19.81	18.58	57.63
	Std.Dev.	6.61	6.96	6.28	17.00
Monthly Cost	Mean	4.81	2.83	4.65	3.84
	Std.Dev.	1.65	.99	1.57	1.13

Source: Edmonton Utilities Records

The consumption and related cost figures outlined in Tables 5-9 and 5-10 support the hypothesis that summer water use will greatly exceed winter water use on a mean monthly basis. Summer season 1969 exceeded the 1969-1970 winter season mean monthly consumption figure by 4,252 gallons (86.8 per cent). For the 1970 summer season, the figure was 3,811 gallons (77.8 per cent) above the 1969-1970 winter season monthly mean. Concerning the cost to the resident for water, the 1969 summer season exceeded the 1969-1970 winter season by 70.0 per cent on a mean monthly basis. The 1970 summer season exceeded the 1969-1970 winter season by 64.3 per cent.

For a sample of ninety-one households, Grima[26] found (to the nearest gallon) a summer period mean of 158 gpd per dwelling unit (standard deviation S.D. of 81) and a winter period mean of 128 gpd per dwelling unit (S.D. 61). For comparison purposes, these figures were each multiplied by thirty to give a mean monthly figure per dwelling unit. Thus the summer and winter means were 4,740 (S.D. 2,430) and 3,840 (S.D. 1,831) gpdu, respectively. Therefore, the mean summer water use is only 23.7 per cent higher than the mean winter water use. Grima partly attributes this lack of a high 'peak' during the summer to the number of days in the billing period (ninety-one and sixty-one days, respectively, for sixty-seven and twenty-four of the sample). The mean summer water use is lowered by the inclusion of some autumn and spring days while the mean winter average is increased by the inclusion of some autumn and spring days. Grima also partly attributes the small 'peak' to a figure of 25 per cent of the sampled households which had a mean summer water use which was lower than that for the preceding or following period. Thus some households were empty for part of the summer. Another explanation is that Toronto would likely have lower summer soil moisture deficits than Edmonton.

Kellow[27] defined his summer season as May to September

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[26] Grima, op. cit., pp. 123, 124 and 126,127.

[27] Kellow, op. cit., p. 85.

and his winter season as October to April. The following figures apply to metered households. The summer season monthly mean was 9,547 gallons (S.D. 5,133) and the winter season monthly mean was 5,527 gallons (S.D. 2,934). The annual mean monthly figure was 7,202 (S.D. 3,502).

By comparing the mean monthly figures for Hardisty and Calgary, Calgary has a higher mean consumption for both the summer and winter seasons. The mean monthly summer season water use exceeded the mean monthly winter season water use by 4,020 gallons (72.7 per cent). Therefore, both the 1969 and 1970 Edmonton summer seasons exceed the 1969-1970 Edmonton winter season by greater percentages than the Calgary summer season exceeded the Calgary winter season (see Table 5-10 for the Edmonton percentage values).

Dunn and Larson[28] did not compute mean values for summer and winter seasons but did estimate mean minimum month and mean maximum month for their sample of 208 households. The mean minimum and maximum monthly values were 90 and 171 gpd, respectively. By multiplying these values by thirty, the mean minimum and maximum monthly values were 2,699 and 5,123 gpdu, respectively. Thus the mean maximum month exceeded the mean minimum month by 89.8 per cent.

E. Lawn Watering and the Price of Water

In response to a hypothetical 10 per cent rise in

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[28]Dunn and Larson, op. cit., p. 448.

price which was proposed in the questionnaire, 77.8 per cent of the 267 people who replied to this question indicated that they would not diminish the amount of water they would use for lawn and shrub watering purposes. During the summer seasons of 1969 and 1970, there were no restrictions placed upon lawn watering practices. But Edmonton Water does produce a brochure[29] outlining beneficial lawn, shrub and plant watering practices. This pamphlet recommends 5 to 9 A.M. as the best time period to water and discourages watering between 5 and 9 P.M. As mentioned previously, the majority of Hardisty residents water their lawns, shrubs and plants between 6 and 9 P.M. Within cities which do impose watering restrictions, a questionnaire could be designed which would seek respondents' reactions to more severe restrictions and enforcement of penalties versus a significantly higher price for water. Such significant price increases, for example 50 per cent, may be the most effective method to reduce water consumption for non household (domestic) uses. For southern Nevada, an arid area, it has been suggested[30] that a feasible method by which to reduce per capita water consumption would

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[29] City of Edmonton, Water for Beautiful Edmonton Lawns. Edmonton, n.d.

[30] W. H. Blackmer, "Supplemental Water Supply for Southern Nevada". Paper presented at the 24th Annual Nevada Water Conference, Sept. 24, 1970, p. 15.

be to increase the water rates about 100 per cent. This would result in a change in the pattern of water use through acceptance of a desert climate and thus less greenery. Presently, approximately 70 per cent of the water use is devoted to uses outside the household.

An important variable in planning residential water distribution systems is water use on the maximum day (W.U.M). The present metering and billing systems hinder the influences of price changes on maximum day use because it is possible for a household to have a low average water use during the summer but a high one day water use.

Summer water use generally includes most winter uses plus others such as sprinkling and swimming pools. A hot, dry summer day includes the water uses of an average summer day plus others such as extra showers, more intensive sprinkling and more use of air conditioners.

Peak demands in a water distribution system are very difficult to accurately predict. Lawn sprinkling demands impose the most critical load on a system. In the Baltimore County study of 1954[31] for houses with lot sizes of 7,200 square feet (the mean Hardisty lot area was 6,845 square feet) the ratio of peak hour to average day use was 1,420 per cent. The number of dwellings in the sample was forty-one with an average of 3.5 persons per dwelling (4.38 persons per

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[31] J. B. Wolff and J. F. Loos, "Analysis of Peak Water Demands". Public Works, Sept., 1956, p. 113.

dwelling in Hardisty). The peak daily and peak hourly demands were 253 and 924 gpcd, respectively. The average daily demand was 70 gpcd (Hardisty, 52.8 gpcd). The ratio of peak hour to peak day was 392 per cent. Such peak hourly and daily demands and ratios will be available for the entire Hardisty area in the autumn of 1971 after Edmonton Water monitors Hardisty during the summer of 1971.

In 1958, an American Water Works Association Task Group presented data on residential water use in five U.S. communities.[32] The peak hourly rate expressed as a percentage of the peak daily rate for lawn sprinkling was 37-70 per cent. When combined with air conditioning, the figures were 48-127 per cent.

Wolff[33] reported in 1961 on the findings of a research project on peak water usage in residential areas of Baltimore County. Two peaks were discovered, one between 7 A.M. and 1 P.M. and the other between 5 and 9 P.M. The season of the year determined when these peaks occurred. The maximum winter hours were between 7 and 9 A.M. and 5 and 7 P.M. Because of sprinkling demands in the spring, summer and early fall, the peaks shifted to the later morning hours and to 6-9 P.M. in the evening. For Hardisty, the majority of residents sprinkled between 6 and 9 P.M.

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[32] Task Group Report, "Study of Domestic Water Use". Journ. A.W.W.A., Nov., 1958, p. 1417.

[33] J. B. Wolff, "Peak Demands in Residential Areas". Journ. A.W.W.A., Oct., 1961, p. 1251.

Wolff in 1961, as in 1956[34] found that sprinkling demand varies with lot size. As previously mentioned, this was also found for Hardisty. Thus Wolff's findings appear to suggest that the design of water systems for residential areas should be a function of lot size rather than of population, if the common pricing method of a declining block rate is continued.

The problem is how to reduce peak hourly demands related to lawn sprinkling. Wolff[35] reported that lawn sprinkling can constitute 80 per cent of peak hourly demand and 75 per cent of the total volume throughout the day. Milliman[36] made several suggestions for reducing sprinkling loads. A seasonal price could be imposed. An increasing block rate for increased use could be adopted. Water rates could be based on lot size. Greater use could be made of ornamental horticulture and landscaping techniques which require less water. Residences could be restricted to the watering of lawns only every other day.

Linaweaver and Geyer[37] made the following recommendations with reference to the reduction of peak demands. A

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[34] Wolff and Loos, op. cit., p. 1251.

[35] Wolff, op. cit., p. 1255.

[36] J. W. Milliman, "Policy Horizons for Future Urban Water Supply". Land Economics, May, 1963, pp. 123-124.

[37] F. P. Linaweaver, Jr., and J. C. Geyer, "Use of Peak Demands in Determination of Residential Rates". Journ. A.W.W.A., Apr., 1964, pp. 409-410.

service charge based upon lot size could be imposed. This charge could be determined from the lot area or from assessed value of land or property. Linaweaver and Geyer suggested this charge should be a direct charge on the water rate schedule and not in proportion to the assessed value. A service charge could be based on fixture counts. Demand metering of residential areas with houses of similar value and with similar lot sizes would aid in eliminating sprinkling inequities.

A two block system of residential water rates could be established. The first block would be based on domestic use and the second block, which would be higher than the first block rate, would be based on sprinkling use. Thus the customer would pay a higher rate, the second block, during a designated lawn watering season. Linaweaver and Geyer[38] estimated the summer water bill for a medium-value house ($19,000 U.S. in 1957) with an average lot size of a quarter of an acre (10,890 square feet) would be three times the average winter bill if all extra-capacity costs were allocated to the second block rate. Therefore, the customer would be encouraged to conserve water during the season of high demand. Also, a study could be made of residential customers' willingness to pay for the extra water system capacity necessary to meet sprinkling demands.

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[38] Ibid., p. 405.

Paraphrasing Howe and Linaweaver[39], higher prices during the summer season may cause customers to use less water per billing period, but this does not diminish peak daily and peak hourly usage. Data on the change of demand with a change in water rates for a given location are very sparse. Flack[40] found no report which adequately accounted for the effect of price increases combined with meter installations. Therefore, it would appear that the effect of metering was inconsistently analysed by researchers. Grima[41] found a reduction in investment requirements of between $24 and $60 per head, depending on the marginal price level, for metering costs.

Grima[42] discussed two pricing methods of reducing peak demands. One is based on seasonal charges. Peak-responsibility charges can be established such that a consumer pays in proportion to the load he places on the peak demand. Peak-load pricing could be established with separate on-peak and off-peak prices. Hopefully, short-term water scarcity during periods of hot, dry summer weather would be reduced and additions to the water supply system to meet peak demands could be postponed.

The second peak reducing method is an increasing

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[39]Howe and Linaweaver, op. cit., p. 29.

[40]Flack, op. cit., p. 1343.

[41]Grima, op. cit., p. 201.

[42]Ibid., pp. 208-211, and 227.

block rate schedule. Such a schedule would permit a small amount of water to be made available to all customers at a low cost. Customers who use a small amount of water and thus contribute very little to the peak demand are not penalized. Customers who use more water, who are able to pay and who cause an increase in the water system capacity are provided with such water but must pay the marginal cost.

The number of billings per annum in Grima's study area was either four or six in the municipalities involved. Seasonal charges would mean an increase in costs since either more meter readers and billing personnel would have to be hired or special meters would have to be purchased and installed. Therefore, an increasing block rate schedule is the most suitable alternative. For Hardisty, a seasonal charge could readily be adopted since meters are presently read monthly. A study would have to be made by Edmonton Water in order to discover which method of reducing peak demands (seasonal charges or increasing block rate) would best suit Edmonton and Hardisty.

Non-price alternatives mentioned by Grima[43] are a reduction in the capacity of household plumbing fixtures and the odd-even rule for lawn watering. Such alternatives are suitable if a temporary reduction in water use is desired.

An opposite point of view is that there should not be a rationing of water. If there is an abundant water

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[43] Ibid., p. 229.

supply and customers are willing to pay for water, no restrictions should be placed on water use. Each city must conduct detailed surveys to determine such factors as the present per capita water use, water wastage (i.e., excessive lawn watering), future urban population, future areas to be served by the water distribution system and sewage treatment costs. If after such detailed surveys no detrimental sanitary, aesthetic or physical reasons can be outlined, no water use restrictions should be imposed on customers.

Of the 260 Hardisty residents who replied to a hypothetical 50 per cent increase in the price of water, 73.4 per cent indicated they would reduce their lawn and shrub watering in accordance with such a price increase. But after a few years, water use may rise to its former level. Much additional research remains to be done in both inter-community and intra-community studies with respect to reducing peak demands.

F. Explanatory Factors of Residential Water Use

The following is a summary of the factors contained in the water use questionnaire (see Appendix B). The average Hardisty household head has lived in this district for over ten years, has the major water-using appliances and plumbing fixtures, waters his lawn between 6 and 9 P.M. for one to two hours and does not have a swimming pool or a wading pool. He shares his house with his wife and two children, works as a services, operative worker or professional-managerial

worker and has three to four years of high school education. He and his family earn between $7,001 and $10,000 per year.

Other explanatory factors, the sources of which are public records, are as follows. The mean Hardisty lot area is 6,845 square feet. The mean non-irrigable area (house, garage, patio) per lot is 1,577 square feet. Thus the mean irrigable area is 5,268 square feet per lot. The mean assessed house value is $4,391.

Dunn and Larson[45] for a sample of 208 households found a close association between water use and occupation, education, family income and assessed valuation. Ware and North[46] (sample size 634 residences) found a mean family size of 3.8 persons, mean annual income of $7,268 and a mean lawn area of 24,100 square feet. They also found that residential water use will increase as incomes increase. Other studies have also found a trend between family income and residential water use. The 1958 Task Group Report[47] and Larson and Hudson[48] found a relationship between family net effective buying income and residential water use. Gottlieb[49] for

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[45]Dunn and Larson, op. cit., p. 445.

[46]Ware and North, op. cit., p. 11.

[47]Task Group Report, op. cit., p. 1410.

[48]Larson and Hudson, op. cit., p. 610.

[49]Gottlieb, op. cit., pp. 208-209.

a Kansas study and Bogue[50] for Detroit also found an income-water use relationship.

Wolff[51] found an apparent increase in average domestic water demands with an increase in consumer economic status. Sprinkling demand varied with lot size, climate and season. Domestic use varied with the number of persons per service. No relationship was found between the number of water-using appliances and plumbing fixtures per residence and the frequency of use.

Linaweaver, Geyer and Wolff[52] found residential water use depends on the number of persons per dwelling unit, the normal domestic water uses, the mean irrigable area of a residential lot, the rate of evapotranspiration and the quantity of precipitation.

For Calgary, Kellow[53] found that as family income, market or assessed house value and number of persons per household increased, average annual water use increased. The amount of water used for lawn sprinkling was directly related to lawn area and to the soil moisture deficit (precipitation minus ET).

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[50] Bogue, op. cit., pp. 549-550.

[51] Wolff, op. cit., p. 1259.

[52] F. P. Linaweaver, Jr., J. C. Geyer and J. B. Wolff, op. cit., p. 281.

[53] Kellow, op. cit., p. 127.

G. Statistical Analysis

A correlation matrix was computed in order to ascertain the interdependence of the variables which were correlated. A linear regression analysis was also used to show the relationship between the dependent variable and each of the independent variables. The dependent variable is the quantity of water used by the Hardisty sample of 271 residences between June, 1969 and August, 1970 (expressed in cubic feet). Ten independent variables were correlated with the dependent variable (signified as X_{11} in Table 5-11) to indicate which variables were closely associated with the quantity of water used. The following (X_1 through X_{10}) are the ten independent variables:

X_1 - date house built.

X_2 - assessed value of house.

X_3 - number of rooms per household.

X_4 - lot size.

X_5 - house size.

X_6 - lot size minus house, garage, patio.

X_7 - number of persons per household.

X_8 - family income.

X_9 - plumbing fixtures.

X_{10} - water-using appliances.

The correlation matrix for water consumption in Hardisty is shown in Table 5-11.

TABLE 5-11

CORRELATION COEFFICIENTS OF WATER CONSUMPTION AND ASSOCIATED FACTORS FOR HARDISTY JUNE, 1969 - AUGUST, 1970

Variable	X_1	X_2	X_3	X_4	X_5	X_6	X_7	X_8	X_9	X_{10}	X_{11}
X_1	1.00	.237	-.037	-.104	.105	-.119	.036	.049	.008	-.026	.005
X_2		1.00	.568	.377	.633	.228	.037	.281	.518	.292	.189
X_3			1.00	.200	.254	.126	.126	.226	.376	.169	.266
X_4				1.00	.291	.969	-.036	.157	.209	.198	.148
X_5					1.00	.159	.045	.193	.422	.136	.103
X_6						1.00	-.056	.135	.131	.169	.116
X_7							1.00	.087	.076	-.033	.467
X_8								1.00	.156	.140	.204
X_9									1.00	.217	.136
X_{10}										1.00	.103
X_{11}											1.00

Three criteria were used to assess the empirical relationship between the dependent and independent variables. These criteria were:

(1) Coefficient of Determination (R^2)

This is the correlation coefficient squared (R^2) and represents the amount of variance that two distributions have in common. The amount of variance in the dependent variable which can be explained by the independent variables increases as the value of R^2 increases.

(2) The Standard Error of Estimate (Sb)

The Sb value is utilized as an expression of the extent to which actual observations deviate from the regression line, the line of average observations. If all points fell on the regression line, the standard error would be zero. If the standard error value equalled the standard deviation value of the dependent variable, there would be no relationship between the variables.

(3) "Student's t" Distribution (t)

The value of t (a standard statistical distribution where t is a function of the mean, standard deviation and the degrees of freedom) is derived by dividing the regression coefficient by its standard error. This value indicates the importance of an independent in estimating the dependent variable. The greater the value of t, the greater the importance.

H. Statistical Results

With 300 degrees of freedom, the value of the correlation coefficient at the 1 per cent level is .148. With 200 degrees of freedom the value at the 1 per cent level is .181. The Hardisty correlations involved 269 degrees of freedom. For the purpose of signifying a value of the correlation coefficient at the 1 per cent level, the value of .148 is used. From Table 5-11, only four variables--house size; lot size minus house, garage, patio; fixtures; and appliances--have correlation values lower than .148.

The various R^2, Sb and t values are shown in Table 5-12. The rank order of each factor is also shown. All factors are ranked in the same order by the three criteria of significance.

Since the Hardisty sample numbered 271, the appropriate number of degrees of freedom is 269. Therefore, from a table[54] showing percentage points of the t distribution, t values corresponding to infinity (∞) degrees of freedom are used. Probability values for two-tailed tests are utilized to test the significance of the independent variables. At ∞ degrees of freedom, the value of t must be as large as 1.960 and 2.576 to be significant at the 5 per cent and 1 per cent probability levels, respectively. Only four factors--date house built; house size; lot size minus house, garage, patio;

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[54] E. S. Pearson and H. O. Hartley (Eds.), Biometrika Tables for Statisticians. Vol. 1, Cambridge University Press, Cambridge, 1954, Table 12.

TABLE 5-12

STATISTICAL SIGNIFICANCE FACTORS AFFECTING HARDISTY RESIDENTIAL WATER USE

Explanatory Factors		R^2 value	Sb value	t value	Rank of each Factor
X_1	(date house built)	.000025	5750	0.08	10
X_2	(assessed house value)	.036	5650	3.10	4
X_3	(number of rooms per household)	.071	5555	4.53	2
X_4	(lot size)	.022	5690	2.40	5
X_5	(house size)	.011	5720	1.69	9
X_6	(lot size minus house, garage, patio)	.013	5710	1.92	7
X_7	(number of persons per household	.218	5090	8.65	1
X_8	(family income)	.042	5630	3.41	3
X_9	(fixtures)	.018	5700	2.25	6
X_{10}	(appliances)	.011	5720	1.70	8

and appliances--are not significant at the 5 per cent probability level. At the 1 per cent probability level, in addition to these four factors only lot size and fixtures are not significant.

The variation in the quantity of water used which can be explained by factors using R^2 values is low. The first ranked factor, number of persons per household, has a R^2 value of only .218. The unexplained variation is 78.2 per cent. The R^2 value of the second ranked factor, number of rooms per household, is only 0.71. Therefore, the R^2 values show a very high percentage variation which cannot be explained by all ten independent variables.

The relationship between the dependent variable and the independent variables as signified by the Sb values is very low. The standard deviation of the dependent variable is 5,742. Since the ten independent variables have Sb values very close to equalizing this standard deviation value, the relationship between the quantity of water used and these ten variables is very small.

The values in Table 5-12 for the R^2 and Sb tests of significance show that the quantity of water used by Hardisty households is not significantly explained by any of the ten factors. The t-test values at the 5 per cent level show that six variables are significant in estimating the amount of water consumed. These six variables are--assessed house value, number of rooms per household, lot size, number of persons per

household, family income and fixtures.

It is difficult to explain why R^2 and Sb values are so low (of low significance). Perhaps the diversity between the individual residences comprising the sample was not great enough to permit R^2 and Sb values of high significance. Additional in depth inquiries into the independent factors affecting Hardisty residential water use may result in significance levels being increased.

CHAPTER VI

SUMMARY AND CONCLUSIONS

This study has three objectives. The first objective is to determine the suitability of mail questionnaires plus public records as pertaining to intra-community, single family residential water use. The second objective is to analyse the responses of residents to hypothetical 10 per cent and 50 per cent price increases as related to water use. The third objective is to evaluate Hardisty water use as related to various explanatory factors which have been noted in other studies.

A. Data Gathering

For Hardisty, the combination of mail questionnaires and public records was a suitable method for gathering the desired data. If the number of mail questionnaires returned had been very small or if many respondents had refused to answer specific questions, personal interviews would have been necessary in an attempt to increase the sample size. The exact monthly water bill consumption and cost figures plus assessment records information closely complemented the questionnaire data. By combining the information obtained from these sources of data, a detailed inventory of Hardisty water use data was made available for analysis.

B. Hypothetical Price Increases

It is difficult to analyse the crosstabulations of hypothetical price increases and various water uses with variables affecting water use as contained in Table 4-7. No other studies have investigated the significance of such crosstabulations in the intra-community residential water use context. The importance of the Hardisty crosstabulations depends on investigations conducted in other study areas. Only through a comparison of several studies and the refining of techniques to measure the significance of responses to hypothetical price increases can the relevance of these crosstabulations be accurately assessed.

C. Correlated Factors

For Hardisty, the highest mean water use was equated to households with the greatest number of people, highest incomes, greatest number of rooms and highest assessment (see Tables 5-3 to 5-6). Climatic factors helped to explain increased water use above the mean monthly figure.

Concerning seasonal water use for Hardisty, the summer season monthly means for 1969 and 1970 greatly exceeded the 1969-1970 winter season monthly mean. Lawn sprinkling was the major factor contributing to these excesses. The price of water should be related to the season of peak hourly and peak daily consumption, namely, the summer season. Possible solutions to peaking problems are seasonal water prices,

an increasing block rate schedule, a service charge based upon lot size, or a two block pricing system with a higher second block imposed during a designated lawn watering season. Detailed studies for individual cities are necessary to reduce peaking problems. Generalizations provide very few solutions.

Correlation and linear regression analyses were performed. Three criteria, the coefficient of determination (R^2), the standard error of estimate (Sb) and "Student's t" distribution (t) were calculated in order to help explain the significance between the quantity of water used per household and each of ten independent variables. The R^2 and Sb tests indicate very low significance levels for all variables. The t values indicate six variables as being significant at the 5 per cent level and four variables significant at the 1 per cent level.

D. Conclusions and Recommendations

The results of the Hardisty residential water use study are not conclusive. Several variables were found to be significant in explaining water use but no variable was significant at the 1 per cent level for all three significance tests employed.

The findings related to hypothetical price increases and water use (by using the chi-squared test) indicate numerous variables which are significant with such price increases. But will consumers react to actual price increases in the same manner? Studies of water price increases and related effects on consumption indicate a wide variation in the amount, if any, of decreases in consumption.

As expected, summer season water use greatly exceeded winter season water use in Hardisty. Lawn sprinkling demands, as conditioned by climatic variables, account for the majority of this difference. The problem of peak hour and peak day consumption is a function of climate and water use habits. Pricing policies are one method through which planners can reduce peaking problems and control water use habits.

The results of the Hardisty study, as with numerous other residential water use studies, are inconclusive. What criteria should be included in studies in an attempt to derive more conclusive results? Future studies should be more stringently controlled, should include a breakdown of cities into smaller units and should be continued over a number of years. The effects of climate and other variables on water use should be studied in more detail in an attempt to more accurately define these effects. The effect of price on water use will also be clarified by these more detailed investigations. An important aspect of water price

studies is the price at which people will reduce water consumption. The responses to the Hardisty hypothetical 50 per cent price increase provide an initial reaction to price increases of this magnitude. An increase in water prices, however, must be viewed in the context of an economy characterized by frequent increases in the prices of almost all commodities and in the context of related salary increases.

The Hardisty study is an attempt to account for water use variations of single family residences within an intra-community context. Hardisty data may permit an increase in the understanding of present water use variations. This study had fulfilled its ends if such data can also help to reduce peaking problems, increase the efficiency of the water system and provide a source of data for future planning.

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APPENDIX A

QUESTIONNAIRE

Dear Sir or Madam:

I am a graduate student in Geography at the University of Alberta. My field of research is residential water use in Edmonton. I would be most grateful if you would complete the enclosed questionnaire. The results of this research will be written up in the form of a Master of Arts thesis. All information will be kept strictly confidential.

Please return the completed questionnaire as soon as conveniently possible in the enclosed self-addressed and stamped envelope.

Thank you very much for your time and co-operation.

Yours very truly,

Neville Ward, B.A.
Graduate Student.

RESIDENTIAL WATER USE QUESTIONNAIRE

Section A

1. How long have you lived at your present address?
   _____years_____months.
2. What is the size of your house? _____square feet

3. Do you have a garage? Yes ___ No ___

   If yes, is it a single ___ or double ___ garage?

4. How many finished rooms are in your house? Please enter bathrooms in the 1/2 room category only.

   ____ finished rooms; ___ finished basement rooms;

   ___ 1/2 rooms

Section B

1. Concerning water appliances for domestic household purposes, which of the following do you have in your home, and if more than one, how many? Please check (✓) the appropriate column(s).

	Appliance	Yes	No	No. if more than one
a)	Automatic clothes washer	___	___	____
b)	Clothes washer (wringer type)..	___	___	____
c)	Automatic dish washer	___	___	____
d)	Food waste (garbage) disposal unit.....	___	___	____
e)	Toilet	___	___	____
f)	Shower	___	___	____
g)	Bathtub.....	___	___	____
h)	Shower/bathtub combination.....	___	___	____
i)	Bathroom sink.....	___	___	____
j)	Kitchen sink - single	___	___	____
	- double	___	___	____
k)	Laundry tub - single	___	___	____
	- double	___	___	____
l)	Water-cooled air conditioner..	___	___	____
m)	Furnace humidifier	___	___	____

Appliance	Yes	No	No. if more than one
n) Portable humidifier	___	___	____
o) Refrigerator with automatic ice-making device	___	___	____
p) Other indoor taps not noted above. Do not count bathroom sinks, kitchen sinks, or laundry tub connections here. (Consider hot and cold as 2 taps.)	___	___	____
q) Outdoor taps	____	___	____
r) Underground watering system for lawn	___	___	____

2. How often do you wash your clothes each week using a washing machine? _____ times per week.

Section C

1. At what time of day do you usually water your lawn?

a) 6 am to 9 am ____
b) 9 am to 12 noon ___
c) 12 noon to 3 pm ___
d) 3 pm to 6 pm ___
e) 6 pm to 9 pm ___
f) 9 pm to 12 midnight ___

2. For what length of time do you water your lawn and garden(s) each day?

a) Less than 1 hour ____
b) 1 to 2 hours ____
c) 2 to 4 hours ____
d) 4 to 6 hours ___
e) more than 6 hours ___

3. For your property, disregarding the amount of land your house occupies, please estimate the amount of land occupied by lawn, shrubs, flower beds, vegetable garden. Estimate in square feet if you wish.

Lawn _____
Flower beds and flower gardens _____
Shrubs _____
Vegetable garden _____

4. Do you have an outdoor swimming pool? Yes ____ No ____

   If yes, what is its size _____ Shape _____

   Capacity _____

5. Do you have a children's wading pool in your backyard?

   Yes ____ No ____

   If yes, how large is it? Size _____ Diameter___ feet

   Depth _____ inches

6. Excluding the area of your house, the majority of your property likely consists of those items listed in question 3 of this section, all of which require water. The following question is asked since the area covered by a patio requires no water.

   Do you have an outdoor patio? Yes____ No ____

   If yes, how large is it? _____feet by _____ feet

Section D

1. What is your opinion about the price you pay for water?

   a) Too high ____ b) Too low ____ c) A fair price ____

2. How much was your water bill for April, 1970? $____.__

3. Please estimate your yearly water bill (disregard sewer surcharges).

   The estimate is $_____

   Let us assume that there is a (A) 10 per cent rise and (B) 50 per cent rise in the price you pay for water. Would you

	10% rise		50% rise	
	Yes	No	Yes	No
a) use less water?.....	___	___	___	____
b) use the same amount of water	___	___	___	____
c) use less water for domestic purposes?	___	___	___	___
d) use less water for lawn shrub, plant watering? ..	___	___	___	___
e) use more water?	___	___	___	___

Section E

1. Please record the number of people in your household who are in the following age groups.

a) 0 to 4 years ____
b) 5 to 9 years ____
c) 10 to 14 years ____
d) 15 to 19 years ____
e) 20 to 24 years ____
f) 25 to 44 years ____
g) 45 to 64 years ____
h) 65+ years ____

2. What is the present occupation or former occupation (if retired) of the head of the household?

Occupation: _____

Does your wife work? Yes ____ No ____

3. What is the total yearly family income before taxes? Include spouse's income in this total; do NOT include the income of any dependents.

a) Less that $3,000 ____
b) $3,001 to $5,000 ____
c) 5,001 to 7,000 ____
d) 7,001 to 10,000 ____
e) 10,001 to 12,500 ____
f) $12,501 to $15,000 ____
g) 15,001 to 17,500 ____
h) 17,501 to 20,000 ____
i) More than $20,000 ____

4. How many years of education does the highest money earner of the household have? Do not consider a dependent's income. Please choose one category from a) to f) and complete category g) only if applicable.

a) 0 to 8 years ____
b) 1 to 2 years of high school ____
c) 3 to 4 years of high school ____
d) 1 to 2 years of university ____
e) 3 to 4 years of university ____
f) More than 4 years of university ____
g) Other kinds of schooling, please specify _____

_____

Thank you very much for taking time to complete this questionnaire.

APPENDIX B

EPARTMENT OF GEOGRAPHY

THE UNIVERSITY OF ALBERTA
EDMONTON 7, CANADA

June, 1970

Dear Sir or Madam:

I am a graduate student in Geography at the University of Alberta conducting research in the field of water resources for a Master of Arts degree. My research is an analysis of residential water uses in the Hardisty District of Edmonton. The results of this research will be written up in the form of a M.A. thesis.

By utilizing questionnaires, it is hoped to establish trends of the residential water uses of Hardisty residents. Your co-operation in completing the enclosed questionnaire will be greatly appreciated as the information you provide will permit valid statements concerning Hardisty water use. I assure you that the information you provide will be regarded as strictly confidential.

Please return the completed questionnaire as soon as conveniently possible in the enclosed self-addressed and stamped envelope.

Thank you very much for your time and co-operation in completing this questionnaire.

Yours very truly,

Neville Ward, B.A.
Graduate Student

HARDISTY RESIDENTIAL WATER USE QUESTIONNAIRE No. ____

Section A

1. How long have you lived at your present address?

   _____ years/ _____ months.

2. Do you have a garage? Yes_____ No_____

   If yes, is it a single_____ or double_____garage?

Section B

1. Concerning water appliances for domestic household purposes, which of the following do you have in your home, and if more than one, how many? Please check (✓) the appropriate column(s).

Appliance	Yes	No	No. if more than one
a) Automatic clothes washer	___	___	_____
b) Clothes washer (wringer type) ...	___	___	_____
c) Automatic dish washer	___	___	_____
d) Food waste (garbage) disposal unit	___	___	_____
e) Toilet	___	___	_____
f) Shower	___	___	_____
g) Bathtub	___	___	_____
Anything entered in h) should not be entered in f) and g).			
h) Shower/bathtub combination	___	___	_____
i) Bathroom sink	___	___	_____
j) Kitchen sink	___		
- single	___	___	_____
- double	___	___	_____
k) Laundry tub			
- single	___	___	_____
- double	___	___	_____
l) Water-cooled air conditioner.....	___	___	_____
m) Furnace humidifier.....	___	___	_____
n) Portable humidifier.....	___	___	_____
o) Refrigerator with automatic ice-making device.....	___	___	_____

Appliance	Yes	No	No. if more than one
p) Other indoor taps not noted above. Do not count bathroom sinks, kitchen sinks, or laundry tub connections here. (Consider hot and cold as 2 taps).....	___	___	____
q) Outdoor taps.....	___	___	____
r) Underground watering system for lawn	___	___	____

2. How often do you wash your clothes each week using a washing machine? _____ times per week.

Section C

1. At what time of day do you usually water your lawn?
   a) 6 am to 9 am ____
   b) 9 am to 12 noon ____
   c) 12 noon to 3 pm ____
   d) 3 pm to 6 pm ____
   e) 6 pm to 9 pm ____
   f) 9 pm to 12 midnight ____

2. For what length of time do you water your lawn and garden(s) each day?
   a) less than 1 hour ____
   b) 1 to 2 hours ____
   c) 2 to 4 hours ____
   d) 4 to 6 hours ____
   e) more than 6 hours ____

3. How many times would you say that you have watered your lawn, garden(s), and shrubs in the last month?
   _____times

4. Do you have an outdoor swimming pool? Yes___ No___
   If yes, what is its Size_____ Shape_____
   Capacity_____

5. Do you have a children's wading pool in your backyard?
   Yes _____ No_____ If yes, how large is it?
   Size_____ Diameter_____feet
   Depth_____inches

6. Excluding the area of your house, the majority of your property likely consists of those items listed in question 3 of this section, all of which require water. The following question is asked since the area covered by a patio requires no water.

6. (continued)

. Do you have an outdoor patio? Yes____ No ___

If yes, how large is it? _____feet by _____feet

Section D

1. What is your opinion about the price you pay for water?

a) Too high ____ b) Too low ____ c) A fair price ____

2. How much was your water bill for May, 1970? $_____

3. Please estimate your yearly water bill (disregard sewer surcharges).

The estimate is $_____.

Let us assume that there is a (A) 10 per cent rise and (B) 50 per cent rise in the price you pay for water. Please put entries in both the 10% rise and 50% rise columns. Would you

		10% Rise		50% Rise	
		Yes	No	Yes	No
a)	use less water?	___	___	___	___
b)	use less water for domestic purposes?	___	___	___	___
c)	use less water for lawn, shrub, plant watering?	___	___	___	___
d)	use the same amount of water?	___	___	___	___

Section E

1. Please record the number of people in your household who are in the following age groups.

a) 0 to 4 years ____
b) 5 to 9 years ____
c) 10 to 14 years ____
d) 15 to 19 years ____
e) 20 to 24 years ____
f) 25 to 44 years ____
g) 45 to 64 years ____
h) 65+ years ____

2. What is the present occupation or former occupation (if retired) of the head of the household?

Occupation:_____

Does your wife work? Yes____ No____

3. What is the total yearly family income before taxes? Include spouse's income in this total; do NOT include the income of any dependents.

a)	Less than $3,000 ____	f)	$12,501 to $15,000 ___
b)	$3,001 to $5,000 ____	g)	15,001 to 17,500 ___
c)	5,001 to 7,000 ____	h)	17,501 to 20,000 ___
d)	10,001 to 12,500 ____	i)	More than 20,000 ___

4. How many years of education does the highest money earner of the household have? Do not consider a dependent's income. Please choose one category from a) to f) and complete category g) only if applicable.

a) 0 to 8 years _____

b) 1 to 2 years of high school _____

c) 3 to 4 years of high school _____

d) 1 to 3 years of university _____

e) University graduate _____

f) Post graduate education _____

g) Other kinds of schooling, please specify _____

_____

Thank you very much for taking time to complete this questionnaire.

DEPARTMENT OF GEOGRAPHY

THE UNIVERSITY OF ALBERTA
EDMONTON 7, CANADA

June, 1970

Dear Sir or Madam:

With regard to the "Hardisty Residential Water Use Questionnaire" sent to you earlier this month, I notice from my files that I have not as yet received your completed questionnaire. I would greatly appreciate you taking a few minutes of your time to complete the Hardisty questionnaire and to return it in the self-addressed and stamped envelope which was provided. The data you provide constitutes the core of my Master of Arts thesis research. In order to obtain meaningful trends concerning Hardisty residential water use, it is very important that all questions be answered and that all questionnaires be returned. You are an important and necessary part of this research.

Please disregard this letter if you have already returned your questionnaire.

Thank you very much for your time in completing the "Hardisty Residential Water Use Questionnaire".

Yours very truly,

Neville Ward, B.A.
Graduate Student

DEPARTMENT OF GEOGRAPHY

THE UNIVERSITY OF ALBERTA
EDMONTON 7, CANADA

July, 1970.

Dear Sir or Madam:

Regarding the "Hardisty Residential Water Use Questionnaire" sent to you in June, as yet I have not received your completed questionnaire. Once again, I would greatly appreciate you taking a few minutes of your time to complete the Hardisty questionnaire. If you have misplaced the copy of the questionnaire which you received, please feel free to telephone me (after 6 pm) at 432-3860 and I will be pleased to send you another copy.

Please disregard this letter if you have already returned your questionnaire.

Thank you very much for your time in providing necessary research data concerning Hardisty residential water use.

Yours very truly,

Neville Ward, B.A.
Graduate Student

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